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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**ENTROPY AND SELF-ORGANIZATION—AN OPEN
SYSTEM APPROACH TO THE ORIGINS OF
HOMELAND SECURITY THREATS**

by

Thomas Kirwan Dobson

June 2015

Thesis Advisor:
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REPORT DOCUMENTATION PAGE			<i>Form Approved OMB No. 0704-0188</i>	
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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE June 2015	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE ENTROPY AND SELF-ORGANIZATION—AN OPEN SYSTEM APPROACH TO THE ORIGINS OF HOMELAND SECURITY THREATS			5. FUNDING NUMBERS	
6. AUTHOR(S) Thomas Kirwan Dobson				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB protocol number ____N/A____.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			12b. DISTRIBUTION CODE A	
13. ABSTRACT (maximum 200 words) This thesis addresses the problem that there is no coherent, unifying paradigm for understanding the origins of homeland security threats. In addition, the thesis asks if the concept of disorder as understood in the dynamics of open, dissipative systems can provide a way of understanding real-world homeland security threats. Ideas from approaches to complex systems based on the idea of dissipative systems were synthesized to create a scalable model of a living social system that imports and exports disorder (entropy) via the transfer of matter, energy, and information. Then, the idea of a dissipative system that exports disorder to its surroundings as it self-organizes was meta-theoretically applied to the processes of self-organization occurring in the world, such as technological advance, population growth, economic growth, and globalization, and can be causally linked to real-world homeland security threats. One conclusion is that, on a descriptive level, the causes of homeland security threats can be modeled as a complex, dissipative system. Another conclusion is that causes of homeland security threats and the means to counter them often lie in complex social, economic, and environmental processes that are well outside the jurisdiction of Department of Homeland Security and the homeland security enterprise, meaning that we should reconsider our approach to homeland security.				
14. SUBJECT TERMS entropy, self-organization, dissipative system, self-organized criticality, complex systems, origin of homeland security threats, asymmetric attack, social entropy theory, living system theory, general system theory			15. NUMBER OF PAGES 129	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU	

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**ENTROPY AND SELF-ORGANIZATION—AN OPEN SYSTEM APPROACH TO
THE ORIGINS OF HOMELAND SECURITY THREATS**

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**MASTER OF ARTS IN SECURITY STUDIES
(HOMELAND SECURITY AND DEFENSE)**

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ABSTRACT

This thesis addresses the problem that there is no coherent, unifying paradigm for understanding the origins of homeland security threats. In addition, the thesis asks if the concept of disorder as understood in the dynamics of open, dissipative systems can provide a way of understanding real-world homeland security threats. Ideas from approaches to complex systems based on the idea of dissipative systems were synthesized to create a scalable model of a living social system that imports and exports disorder (entropy) via the transfer of matter, energy, and information. Then, the idea of a dissipative system that exports disorder to its surroundings as it self-organizes was meta-theoretically applied to the processes of self-organization occurring in the world, such as technological advance, population growth, economic growth, and globalization, and can be causally linked to real-world homeland security threats. One conclusion is that, on a descriptive level, the causes of homeland security threats can be modeled as a complex, dissipative system. Another conclusion is that causes of homeland security threats and the means to counter them often lie in complex social, economic, and environmental processes that are well outside the jurisdiction of Department of Homeland Security and the homeland security enterprise, meaning that we should reconsider our approach to homeland security.

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LIST OF ACRONYMS AND ABBREVIATIONS

ASEAN	Association of Southeastern Asian Nations
CAN	Andean Community
CARICOM	Caribbean Community
CEFTA	Central European Free Trade Area
CIKR	critical infrastructure and key resources
DHS	Department of Homeland Security
EIPLOTS	environment, information, population, level of learning, organization, technology, and spatial area
ELF	Earth Liberation Front
EU	European Union
FDI	foreign direct investment
GDP	gross domestic product
GST	general system theory
IMF	International Monetary Fund
ISIS	Islamic State of Iraq and Syria
LST	living system theory
MCCA	Central American Common Market
MERCOSUR	Southern Common Market
OECD	Organization for Economic Cooperation and Development
PETA	People for the Ethical Treatment of Animals
PILOTS	population, information, level of living, organization, technology and spatial area
PISTOL	population, information, spatial area, technology, organization and level of living
PLA	[Chinese] People's Liberation Army
SET	social entropy theory
SSA	social structure of accumulation
WMD	weapon of mass destruction
WTO	World Trade Organization
WWII	World War II

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EXECUTIVE SUMMARY

Homeland security is a relatively new concept.¹ There is currently not a single definition of homeland security agreed upon by academics and practitioners at the federal, state, and local levels.² However, homeland security is operationally defined by the practices of the Department of Homeland Security and state and local governments.³ Furthermore, while the meaning of homeland security may be understood differently by various actors, for the most part there is a growing awareness that the actions taken at different levels of government are related and that together they form a homeland security enterprise.⁴ This awareness of an emerging overall enterprise for dealing with homeland security helps to bring coherence and coordination to homeland security strategy and practice because the different parts of the homeland security enterprise can better understand how what they do interrelates with the activities of the other parts of the enterprise.

Currently, there is not a similar unified approach to the understanding of homeland security threats. The threats are divided into major categories, such as terrorism, threats to critical infrastructure, threats related to climate change, and the threat of economic instability, but there is no overall concept to unify them as there is with the homeland security enterprise. This matters because the homeland security enterprise and homeland security threats are also interrelated. What the homeland security enterprise does affects the threats, and the threats affect the enterprise. This means that our understanding of causes of homeland security threats has a direct impact on our ability to cope with them. This leads to this question: Is there a unifying concept out there that can bring coherence to our understanding of homeland security threats that can in turn bring more coherence to the activities of the homeland security enterprise?

¹ Christopher Bellavita and Ellen Gordon, "Changing Homeland Security: Teaching the Core," *Homeland Security Affairs* II, no. 1 (2006): 1.

² Ibid.

³ Department of Homeland Security, "Homeland Security Enterprise," last modified December 12, 2014, accessed January 28, 2015, <http://www.dhs.gov/homeland-security-enterprise>

⁴ Ibid.

As mentioned earlier, homeland security threats are diverse; however, one thing that they all have in common is that are all forms of disorder. Disorder, understood as the thermodynamic concept of entropy, has been extensively studied. The second law of thermodynamics or entropy law states that when work is done on a system, entropy or disorder always increases.⁵ This implies that all systems should quickly disintegrate into disorder, which is clearly not the case, as evidenced by complex organisms that maintain themselves far from equilibrium for long periods of time. This contradiction is resolved by revisiting assumptions. The entropy law was first formulated assuming a closed system, but almost all systems in nature are actually open. Ilya Prigogine, a physical chemist, reformulated the entropy law, assuming an open system that allows for the importation of matter and energy. Prigogine observed that flows of matter and energy can give rise localized self-organization as the system dissipates energy, and for this reason named the systems dissipative systems.⁶ The entropy law still holds, however, and that means that total entropy still increases. This means that the self-organization in the dissipative system comes at the expense of increased disorder outside the system.⁷ Another way of looking at it is that the self-organizing part of the dissipative system transfers its disorder to its surroundings, increasing disorder there. Due to its ability to reconcile the entropy law with the existence of complex systems in the world, the idea of a dissipative system is a foundational concept for several approaches to understanding complex systems, such as general system theory, living system theory, and social entropy theory.⁸ This raises an interesting question: Can the idea of dissipative systems be used to understand homeland security threats in terms of the entropy, or disorder, that arises as a byproduct of processes of self-organization occurring in the world?

⁵ Rudolf Clausius, *The Mechanical Theory of Heat—With its Applications to the Steam Engine and to Physical Properties of Bodies* (London: John van Voorst, 1867), 365

⁶ Ilya Prigogine, Gregoire Micolis, and Agnes Babloyantz, “Thermodynamics of Evolution,” *Physics Today* 25, no. 11 (1972): 24.

⁷ Ibid.

⁸ Kenneth D. Bailey, *Social Entropy Theory* (Albany, NY: State University of New York Press, 1990), 81; Kenneth D. Bailey, “Living Systems Theory and Social Entropy Theory,” *Systems Research and Behavioral Science* (2006): 299; Ludwig von Bertalanffy, “The Theory of Open Systems in Physics and Biology,” *Science, New Series* 111, no. 2872 (1950): 26.

Another characteristic of dissipative systems, self-organized criticality⁹ also has a major impact on systems related to homeland security. Self-organized criticality refers to a tendency of some systems to naturally self-organize into a critical state far from equilibrium at which any change can result in cascading chain reactions of different sizes.¹⁰ Examples of events that result from self-organized criticality include landslides, earthquakes, disease pandemics, financial meltdowns, forest fires, and breakdowns of various kinds of critical infrastructure.¹¹

Other ideas from thermodynamics that can be meta-theoretically applied to homeland security is the idea from social entropy theory and living system theory that money can be used as a maker for entropy transfers in social and economic systems.¹² Another is the idea of free energy from thermodynamics applied to social systems as social free energy. Social free energy is amount of energy beyond the amount needed to maintain the structure of a social system.¹³ This makes social free energy the amount of energy available to deal with threats to that structure or, in other words, a rough measure of overall resilience. Since flows of money correspond to flows of entropy, the financial statistics of an organization describe entropy flows occurring within it and its overall entropy balance. Borrowing represents importing the means to reverse entropy, or disorder, in the present, and therefore the accumulation of debt represents an obligation to repay the means of reversing entropy in the future. In other words, accumulating debt represents future importations of entropy.

Systems ideas from social entropy theory, living system theory, and general system theory provide a means for relating the concept of dissipative systems to

⁹ Per Bak, Chao Tang, and Kurt Wiesenfeld, "Self-organized Criticality," *Physical Review* (1988): 364–373.

¹⁰ Per Bak and Kim Sneppen, "Punctuated Equilibrium and Criticality in a Simple Model of Evolution," *Physical Review Letters* 71, no. 24 (1993): 4083.

¹¹ Donald L. Turcotte, "Self-organized Criticality," *Reports on Progress in Physics* (1999): 1416–1417.

¹² Gale Alden Swanson, Kenneth D. Bailey, and James Grier Miller. "Money: A Living Systems Theory Perspective," *Systems Research and Behavioral Science* 14, no. 1 (1997): 45–65.

¹³ Josip Stephanic, Jr., "Describing Social Systems Using Social Free Energy and Social Entropy," *Kybernetes* 34, no. 5/6 (2005): 862.

homeland security threats that are occurring in the real world. Ideas from these approaches to complex systems were synthesized to show how flows of matter, energy, and information (and objects made from these components) can result in transfers of entropy among the environmental, social, and economic aspects of a living social system and its external environment. These entropy transfers can occur incidentally as a result of passive or voluntary exchanges of matter, energy, and information, or by means of strategically directed, even violent transfers of entropy.

To illustrate how the homeland security threats facing U.S. can be modeled as a dissipative system, we have to say how self-organization in one place is leading to disorder in another. Threats to homeland security can come from anywhere in the world. This means that in order to understand the origins of these homeland security threats, we first have to describe the main currents of self-organization occurring in the world and then causally relate them to real-world homeland security threats.

The main dynamics of self-organization in the world today covered in this paper, population growth, advance of technology, and economic growth, are interrelated and mutually causal with each other.¹⁴ The process of globalization is related to these mega-trends. Globalization is modeled as a positive feedback loop composed of globalization leading to the perception of the benefits of globalism, which leads to global and regional institution building, resulting in more globalization. Globalization is related to the mega-trends because it is a main driver of economic growth.

The mega-trends give rise to homeland security threats through causal linkages. For example, population growth leads to more resource use,¹⁵ which, in the case of increasing use of fossil fuels, leads to greenhouse gas buildup and ultimately the threat of the effects of climate change.¹⁶ At the same time, increased resource use also leads to environmental degradation, which, through complex social processes, has resulted in the

¹⁴ Bailey, *Social Entropy Theory*, 99–100.

¹⁵ United Nations Fund for Population Activities, “Linking Population, Poverty, and Development,” accessed October 28, 2013, <http://www.unfpa.org/pds/trends.htm>, 1–2.

¹⁶ Lori M. Hunter, *Population and Environment: A Complex Relationship* (Santa Monica, CA: RAND, 2012), accessed November 17, 2013, http://www.rand.org/pubs/research_briefs/RB5045/index1.html, 3.

development of radical environmentalism and the threat of eco-terrorism.¹⁷ Similar causal linkages are explained and illustrated in a diagram called a trend map, which shows how the processes of self-organization gives rise to other homeland security threats, such as the threat of identity based conflict and terrorism, pandemic, weapons of mass destruction, nuclear, chemical or biological attack, cyber-attack, threats from international organized crime, economic instability, supply-chain attacks, civil conflict, or asymmetrical attacks. To see the diagram and a full explanation of all these causal linkages, please read the full thesis.

A conclusion of the thesis is that homeland security threats can be understood in terms of the dynamics of a dissipative system. Also, the thesis illustrates that there are multiple, mutually reinforcing causal relationships among factors arising from the mega-trends that give rise to homeland security threats. This makes the relationship between the self-organization occurring in the world and the resulting homeland security threats complex, and the overall system, a complex system. This unified understanding of the origin and underlying causes of homeland security threats can be useful when formulating homeland security strategy and tactics.

The thesis has documented how social, economic, and environmental processes affect the origins of homeland security threats. Many of these processes are well outside the jurisdiction of the homeland security enterprise. This implies that we may need to evaluate current thinking about the relationship between homeland security threats and the homeland security enterprise.

¹⁷ Horacio R. Trujillo, "The Radical Environmentalist Movement," in *Aptitued for Destruction, Vol. 2 Case Studies of Organizational Learning in Five Terrorist Groups*, ed. Brian A. Jackson et al. (141–175) (Santa Monica: RAND, 2005), 151.

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ACKNOWLEDGMENTS

The time I have spent on this thesis could not be spent with my family, so I must acknowledge first the sacrifices that they have made on my behalf. This is true of my daughters, Ruta and Audra, but especially true of my wife, Roma, who, during the course of this program, was diagnosed with breast cancer, underwent surgery, did chemotherapy, then rehabilitation, and is only now recovering fully.

I would also like to thank my supervisor and friend, Rosemary Davis, who believed in the benefit of my participation in the program and gave me the support and time to make the most of it.

Finally, I would like to thank my advisor, Ryan Ellis; second reader, Chris Bellavita; and research instructor, Lauren Wollman, all of whom knew how to strike the balance between giving me the freedom to pursue my ideas to their fullest potential, while also keeping me properly grounded in method and rigor.

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I. INTRODUCTION

The total disorder in the universe, as measured by the quantity that physicists call entropy, increases steadily as we go from past to future. On the other hand, the total order in the universe, as measured by the complexity and permanence of organized structures, also increases steadily as we go from past to future.

Freeman Dyson¹

A. WHY WE NEED A UNIFIED UNDERSTANDING OF HOMELAND SECURITY THREATS

The events of 9–11 made our nation aware of the homeland security threats we face and led to the creation of the Department of Homeland Security (DHS). DHS and the homeland security threats it confronts are interrelated. Our ability to properly understand homeland security threats and their origin directly impacts our ability to prevent or mitigate these threats. “Homeland security” is a relatively new² and broad concept that currently lacks a single, established definition that has been stable over time. A definition from the 2012 DHS Strategic Plan that we will use for this paper is “efforts to ensure a homeland that is safe, secure, and resilient against terrorism and other hazards.”³

DHS, along with partners in state, local, and tribal governments, has also operationally defined homeland security through its policies.⁴ Practitioners associated with different aspects of homeland security think of homeland security within the contexts of the challenges they face and their own experience. Even so, there is growing degree of shared vision, a commonality of thinking, however imperfect, about how these

¹ “Freeman Dyson,” accessed March 27, 2015, http://todayinsci.com/D/Dyson_Freeman/DysonFreeman-Quotations.htm.

² Christopher Bellavita and Ellen Gordon, “Changing Homeland Security: Teaching the Core,” *Homeland Security Affairs* II, no. 1 (2006): 1.

³ Shawn Reese, *Defining Homeland Security: Analysis and Congressional Considerations* (Washington, DC: Congressional Research Service, 2013), 8.

⁴ Department of Homeland Security, “Homeland Security Enterprise,” last modified December 12, 2014, accessed January 28, 2015, <http://www.dhs.gov/homeland-security-enterprise>.

different parts connect and relate to each other. The result of this common vision is an emerging, integrated homeland security enterprise.⁵

There is not yet a unifying idea that connects major changes occurring in the world with real-world homeland security threats and combines them into a unified whole. Homeland security threats are studied extensively but are seen largely as separate fields of inquiry. In the context of the parable of the *blind men and the elephant*,⁶ the men feel a pillar, tail, wall, or fan, and not a single animal—as with the homeland security enterprise.

This matters because the understanding of homeland security threats impacts the functioning of the homeland security enterprise. Changes occurring in the world, such as technological advance, population growth, economic growth, and globalization, may underlie the root causes of homeland security threats. Understanding how social, economic, and environmental factors are related to homeland security threats may allow us to see how government policy beyond the scope of the homeland security enterprise impacts homeland security threats. This could lead to the creation of new cognitive approaches or policy tools to eliminate or mitigate homeland security threats, perhaps even at the level of their root causes. A key step towards developing these tools is learning to see homeland security threats, and the global processes and trends that are shaping them, as a single, integrated animal.

The task of this thesis is to try to help people concerned about homeland security to visualize the homeland security threat elephant. It will first suggest the possibility that the threats we are touching may indeed be parts of the same animal. Then, using some theoretical approaches and facts, it will put together a picture of what that animal might look like—in other words, suggest a pattern in the gestalt. Detailing the exact physiology of the elephant, or even conclusively proving its existence, is beyond the scope of what is possible in this paper. The intent is to give people a tool that they can use in their analyses. If we are able to show how different homeland security threats, such as

⁵ Ibid.

⁶ “Blind Men and an Elephant,” *Wikipedia*, last modified February 6, 2015, accessed February 13, 2015, http://en.wikipedia.org/wiki/Blind_men_and_an_elephant.

terrorism, pandemic, environmental degradation and climate change, economic instability, and the threat of cyber-attack, can be related to the same fundamental changes occurring in the world today, the resulting understanding may be useful for homeland security analysis.

The results of this analysis can then be used to re-examine our thinking about the subject of homeland security and the homeland security enterprise. Have we properly understood “homeland security threats?” Are we seeing isolated threats, or are they symptoms of larger, interrelated global processes that are shaping our world? If we are currently actually treating symptoms rather than dealing with root causes, do we need to change our thinking about the homeland security enterprise and the role of government in homeland security? If so, how?

As mentioned earlier, the concept of homeland security is still under debate. This means that the relationship between homeland security and national security is also somewhat murky. If homeland security threats are linked to large scale global changes, might national security threats also be affected by these same changes? If so, can this tell us anything about the proper relationship between homeland security and national security?

This paper will suggest a unified approach to understanding homeland security threats by providing an analysis and conceptual tools that can help to identify and understand common root causes of homeland security threats. Now we will turn to the task of finding approach to the causes of homeland security threats.

B. HOMELAND SECURITY THREATS AS DISORDER

Homeland security threats are diverse. They include such threats as terrorism, climate change and natural disasters, pandemics, attacks with weapons of mass destruction, cyber-attack, economic instability, and threats posed by organized crime.⁷ These threats do have something in common, however, and that is that they are all forms

⁷ Department of Homeland Security [DHS], *Quadrennial Homeland Security Review Executive Summary*, 2010, accessed November 8, 2013, http://www.dhs.gov/xlibrary/assets/qhsr_executive_summary.pdf.

of disorder. Perhaps if we can understand the “disorder” in the world in a coherent and unified way, then this could be a basis for conceptualizing homeland security threats. Another word for “disorder” is entropy. Entropy is a concept from thermodynamics that has been extensively studied, and it is also a foundational concept for several approaches to the study of systems, many of which can be directly related to processes underlying real-world homeland security threats.

Can the concept of entropy provide a basis for a coherent and unified approach to understanding the origins of homeland security threats, and if so, how? In order to seek answers to these questions, this paper will borrow the concept of entropy and other theoretical approaches based on entropy and apply them to social, economic, and environmental topics of relevance to homeland security. In order to lay the foundation necessary for what follows, we will now explore entropy and related systems concepts in more detail.

II. THEORETICAL FOUNDATIONS

[A living organism] ... feeds upon negative entropy ... Thus, the device by which an organism maintains itself stationary at a fairly high level of orderliness (= fairly low level of entropy) really consists in continually sucking orderliness from its environment.

Erwin Schrodinger⁸

This chapter will establish the building blocks for synthesis and analysis that follows. It will identify and highlight the main concepts that will be useful in investigating whether causal linkages can be found between major real-world processes of self-organization and homeland security threats, including:

- Explaining the idea of entropy and how it works in closed and open systems.
- Identifying significant theoretical approaches to understanding complex systems based on entropy in open systems that can later be incorporated into a simple scalable model to describe transfers of entropy within and among systems.
- Providing examples of theoretical approaches to social, economic, and environmental topics that are descriptively similar to the characteristics of open systems and can be related to homeland security threats.

A. INTRODUCTION TO ENTROPY AND DISSIPATIVE SYSTEMS

The Second Law of Thermodynamics: The entropy of the universe tends to a maximum.

Rudolf Clausius⁹

The most famous expression of the second law of thermodynamics, or entropy law, as expressed above by Clausius, means that any time energy is used, the total entropy, or disorder, in the universe increases. As an idea, “entropy” has gone through

⁸ Erwin Schrodinger, “What is Life? The Physical Aspect of the Living Cell,” 1944, http://whatislife.stanford.edu/LoCo_files/What-is-Life.pdf, 73–75.

⁹ Rudolf Clausius, *The Mechanical Theory of Heat—With its Applications to the Steam Engine and to Physical Properties of Bodies* (London: John van Voorst, 1867), 365.

different stages of development. The second law of thermodynamics has been defined and applied in different ways as the idea of entropy has developed. The entropy law was introduced by Clausius, who was studying steam engines. He observed that heat cannot be completely converted into mechanical work.¹⁰ Some of the energy was always lost to friction, dissipated to ambient temperature, or in other ways. Clausius also noticed that heat travels from hot to cold and not the other direction. This heat loss is “irreversible” because heat cannot travel from a cold reservoir to a hot one unless some kind of work is done on it—additional energy must be expended to make that happen.¹¹ This concept of “irreversibility” remains fundamental to thinking about entropy, and it has been incorporated into thinking about social, economic, and environmental topics. For example, a new technology can change economic organization and production in irreversible ways; people will not go back to using the telegraph now that the Internet has been invented, and whale oil will never again be economically viable as a source of light now that the incandescent light and the power grids needed to deliver electricity to every home have been invented. Threats to homeland security are irreversible in a similar way. Terrorists will not forget the techniques they have learned for using the Internet for dissemination of information and tactical coordination, and homeland security practitioners will have to develop new ways of countering these threats.

Ludwig Boltzmann thought about entropy in terms of the probability of the occurrence of a particular state of a system. From this way of thinking, maximum entropy is associated with the state with the largest probability of occurring.¹² This most probable state is also the most random state, meaning that entropy describes a state of randomness or disorder. This way of thinking about entropy allows entropy to be described in terms of statistics and statistical mechanics. Later in this paper, concepts from statistical systems will be applied to the causes of homeland security threats.

¹⁰ Lucien Benguigui, “The Different Paths to Entropy,” *European Journal of Physics* 34, no. 2 (2013): 303–323.

¹¹ *Ibid.*, 6.

¹² *Ibid.*, 8.

J. Willard Gibbs related entropy to potential energy, or “potential” by the relationship that, for a closed system in equilibrium, the potential will tend towards a minimum, while the entropy is “maximal,”¹³ which, in the case of a closed system, means the system will tend towards maximum disorder or total randomness. The notion that systems naturally tend towards disorder and that many homeland security threats can be understood in terms of disorder are fundamental premises of this paper.

There is a basic contradiction between the idea of entropy described above and the existence of complex living organisms and other structures that are obviously highly organized and remain far from equilibrium for long periods of time. If systems tend toward randomness and disorder, how can the existence of these highly complex organisms be explained?

This problem can be resolved by revisiting assumptions. The entropy law as explained above assumes a closed system. Actually, practically all systems in nature are open. A chemist named Ilya Prigogine formulated an extended version of the entropy law that applies for both open and closed systems. “Open” means that the system can exchange matter and energy with its outside surroundings.¹⁴ Prigogine observed that structures can form spontaneously due to the continuous flow of matter and energy from the outside world. The maintenance of these structures results in a certain level of energy dissipation, or energy loss to the surroundings, so Prigogine called the resulting structures “dissipative structures.”¹⁵ Furthermore, Prigogine noted that dissipative systems can maintain a stable form within certain steady state conditions, but if the steady state regime becomes unstable because of changes in the flow of matter and energy, the system can progress through a hierarchy of more complex and organized states:

¹³ Ibid., 22.

¹⁴ In equation form, Prigogine’s extended version of the Clausius-Carnot inequality governing the variation of entropy (for a closed system) during a time interval it takes the form:

$$ds = deS + diS, \quad diS > 0$$

where deS is the flow of entropy due to exchanges with the surroundings and diS is the entropy production due to irreversible processes inside the system such as diffusion, chemical reactions, heat conduction, and so on.” Ilya Prigogine, Gregoire Micolis, and Agnes Babloyantz “Thermodynamics of Evolution,” *Physics Today* 25, no. 11 (1972): 24.

¹⁵ Ibid., 25.

[The]system may evolve through a whole succession of transitions leading to a hierarchy of more and more complex and organized states. Such transitions can arise in nonlinear systems that are maintained far from equilibrium: that is, beyond a certain critical threshold the steady-state regime become unstable and the system evolves into a new configuration.¹⁶

The entropy law still holds, however, and this means that while a flow of matter and energy can cause and maintain self-organization in an open system, total entropy, or disorder, in the world must still increase. The transfer of matter and energy into the system facilitates order within the system. At the same time, the matter and energy that enter the system are no longer available to maintain order outside the system, so the entropy outside the system increases. Another way of looking at it (and this is a key point to understanding this paper) is that *flows of matter and energy into the system facilitate the transfer of disorder from the system to its surroundings*. As the system self-organizes, it exports its disorder. If we look at homeland security threats in terms of transfers of disorder, then we may have a way of linking homeland security threats to processes of self-organization that are occurring in the world.

Applying the idea of dissipative systems to homeland security could provide coherence and unity to our understanding of homeland security threats in the following ways:

- The idea of dissipative systems can explain not only how things become disordered, but ordered as well. This linkage between self-organization and disorder provides great flexibility analyzing the causes of homeland security threats, because the threats can be understood in terms of either self-organization or disorder.
- Dissipative systems are a foundational component of several approaches to understanding complex systems, such as the general systems theory, living systems theory, and social entropy theory, which provide a rich foundation of concepts that relate directly to homeland security threats. More on this later.
- Self-organizing criticality¹⁷ is a characteristic of dissipative systems which applies to many systems of homeland security significance, such as critical

¹⁶ Ibid.

¹⁷ Per Bak, Chao Tang and Kurt Wiesenfeld, "Self-organized Criticality," *Physical Review* (1988): 365.

infrastructure, ecological systems, financial and economic systems, and others. More on this later, as well.

B. APPROACHES TO OPEN SYSTEMS

The idea of dissipative systems is a foundational concept for several approaches to understanding complex systems: general systems theory (GST), living systems theory (LST), and social entropy theory (SET). GST, LST, and SET all explicitly base their approaches to the systems that they study on Prigogine's concept of a dissipative system.¹⁸ These approaches to open systems provide a more detailed theoretical structure based on dissipative systems that can be applied to understanding how fundamental processes operating in the world may also be giving rise to homeland security threats.

Ludwig Bertalanffy, founder of GST, noted that although science tends to be specialized, similar problems and conceptions are found in totally different fields.¹⁹ To Bertalanffy, this "parallelism of general cognitive principles" is remarkable because of its usefulness and because these "parallel cognitive principles" were often developed independently in different branches of science. Bertalanffy hoped to use GST to increase the unity of science. He believed that these "general cognitive principles" are valid for systems in general and used them as the basis for GST.²⁰ Additionally, he identified certain "classes or complexes of systems" that are found widely in various kinds of systems found in different branches of science²¹ and called these structural similarities among sciences "isomorphisms."²²

Bertalanffy sees a hierarchy under which higher order systems maintain themselves by breaking down the systems of the next lower level: chemical compounds in the cell, cells by multi-cellular organisms, and individual organisms by ecological

¹⁸ Kenneth D. Bailey, *Social Entropy Theory* (Albany, NY: State University of New York Press, 1990), 81; Kenneth D. Bailey, "Living Systems Theory and Social Entropy Theory," *Systems Research and Behavioral Science* (2006): 299; Ludwig von Bertalanffy, "The Theory of Open Systems in Physics and Biology," *Science, New Series* 111, no. 2872 (1950): 26.

¹⁹ *Ibid.*, 30.

²⁰ *Ibid.*, 32.

²¹ *Ibid.*, 139.

²² *Ibid.*, 33.

systems.²³ Similarly, LST identifies a hierarchy of eight levels of living systems: cell, organ, organism, group, organization, community, society, and supranational system.²⁴ LST also adds “information” to matter and energy as inputs that can counter entropy and facilitate self-organization²⁵ in a dissipative system.

SET also considers “information” as a factor contributing to self-organization along with matter and energy. SET initially defined six global macro-sociological variables—population, information, spatial area, technology, organization, and level of living, or (PISTOL).²⁶ Kenneth Bailey, the creator of SET, noted that SET and LST are compatible and went on to identify the areas of overlap and congruence between SET and LST. In the process, Bailey determined that SET was enhanced by explicitly adding the variable E (for matter-energy) to PILOTS (PISTOL rearranged into a different word) to make EILOTS.²⁷ These macro-sociological variables are seen as being “related reciprocally or in a state of interdependence or mutual causation”²⁸ with the possibility of positive and negative feedback.²⁹ Bailey asserts that the six macro-sociological variables can be split into other variables.³⁰ To apply these macro-sociological variables to the homeland security environment, it will be necessary to combine and split these variables in order to match them with the factors of real world processes.

C. SELF-ORGANIZED CRITICALITY

Self-organized criticality is another characteristic of dissipative systems³¹ with major homeland security implications. “Self-organized” refers to the tendency of the

²³ Ibid., 140.

²⁴ Ibid. 158.

²⁵ James Grier Miller and Jesse L. Miller, “Introduction: The Nature of Living Systems,” *Behavior Science* 35 (1990): 157.

²⁶ Ibid. 90–96.

²⁷ Ibid. 298–299.

²⁸ Bailey, *Social Entropy Theory*, 99.

²⁹ Ibid., 100.

³⁰ Ibid., 105.

³¹ Bak, Tang and Wiesenfeld, “Self-organized Criticality,” 364–373.

systems to naturally organize themselves into a critical state far from equilibrium³² independently of initial conditions.³³ Once this state has been reached, any change to the system results in cascading chain reactions of all sizes.³⁴

Ted Lewis takes a network approach to understanding self-organized criticality. “Percolation” is the process of adding links and nodes to the system, or network.³⁵ Over time, nodes and links become increasingly integrated until the system reaches a critical state where a disturbance can propagate throughout the entire system causing a “catastrophic disruption.”³⁶ The system becomes stable when it has been disrupted enough so that the “noise signal” can no longer propagate effectively.³⁷

Complex systems tend to become more structured or organized as they age, and old or highly evolved systems tend to accumulate more self-organized criticality.³⁸ Unless energy is expended to avoid the buildup of self-organized criticality, it will increase and eventually the system will reach a critical point.³⁹

Self-organized, critical systems follow a mathematical power law.⁴⁰ Power laws are related to the idea of randomness or statistical entropy. Oded Kafri modeled entropy mathematically with a probability function based on “a fair and unbiased random distribution of particles in boxes.”⁴¹ Kafri discovered that when the number of particles

³² Per Bak and Kim Sneppen, “Punctuated Equilibrium and Criticality in a Simple Model of Evolution,” *Physical Review Letters* 71, no. 24 (1993): 4083.

³³ Ibid., 365.

³⁴ Ted G. Lewis, *Bak’s Sand Pile* (Williams, CA: Agile Press, 2011), 364.

³⁵ Ibid., 363.

³⁶ Ibid., 362.

³⁷ Bak, Tang, and Wiesenfeld, “Self-organized Criticality,” 367.

³⁸ Lewis, *Bak’s Sand Pile*, 120–121.

³⁹ Ibid.

⁴⁰ According to Bak, Tang, and Wiesenfeld, “The general arguments and numerical simulations show that dissipative dynamical systems with extended degrees of freedom can evolve towards a self-organized critical state, with spatial and temporal power law scaling behavior. The spatial scaling leads to self-similar ‘fractal’ structure. The frequency spectrum of $1/f$ noise or flicker noise with a power-law spectrum $S(f) \approx f^{-\beta}$.” Bak, Tang, and Wiesenfeld, “Self-organized Criticality,” 364.

⁴¹ Oded Kafri, “The Distributions in Nature and Entropy Principle,” Cornell University Library, July 28, 2009, accessed December 29, 2014, <http://arxiv.org/abs/0907.4852>.

boxes exceeds the number of particles, the result is a bell curve.⁴² When the number of particles exceeds the number of boxes, however, the result is a power law.⁴³ This is because as the number of particles becomes larger relative to the number of boxes, there can be an increasingly large number of outliers on the extreme right hand side of the graph. On the left hand side of the graph the likelihood cannot become less than 0, and so there cannot be similar outliers on this side. This allows the right side of the graph to develop a “long tail” while the left hand side cannot. Kafri concludes that both the bell curve and power curve are results of the “tendency of statistical systems to maximize entropy.”⁴⁴

The concept of a dissipative system is a convergence between the idea of randomness, entropy, disorder, and destruction on the one hand, and the maintenance of order on the other. Dissipative systems use inputs of matter, energy, and information to build and maintain structure. They behave as if they have the specific goal of dissipating energy because the more energy they receive, the more structure they can build and maintain, and the more energy they can dissipate. Dissipative systems that experience self-organized criticality seem to take this logic a bit farther because they build, destroy, then rebuild complex structure. The repeated building, destruction, and then rebuilding of structure seems to be more effective at dissipating energy than simply building and maintaining structure. The result is randomly distributed “bursts”⁴⁵ of destruction, which can be violent, even catastrophic. Catastrophes of sufficient magnitude can fundamentally alter affected systems. Given the widespread nature of self-organized criticality in many systems in the world, and the impact of catastrophes it causes, Lewis calls the reality produced by the effects of self-organized criticality “punctuated reality.”⁴⁶

Self-organized criticality has been observed in many systems that have direct relevance to homeland security. Manifestations of self-organized criticality include

⁴² Ibid., 13.

⁴³ Ibid.

⁴⁴ Ibid., 1.

⁴⁵ Lewis, *Bak's Sand Pile*, 22.

⁴⁶ Ibid.

financial meltdowns, earthquakes, forest fires, disease pandemics, breakdowns of various types of critical infrastructure, species extinctions,⁴⁷ and even long cycles in economic, political, social, and cultural processes.⁴⁸ Before applying these ideas related to dissipative systems to the task of understanding real-world homeland security threats, we need to ascertain the limits inherent to this approach. A review of the results of attempts to model other real world social, economic, and environmental systems as dissipative systems can provide valuable insight into this question.

D. EXPERIENCE IN MODELING SOCIAL, ECONOMIC, AND ENVIRONMENTAL SYSTEMS AS DISSIPATIVE SYSTEMS

The dissipative system is a foundational concept to the systems approaches mentioned previously and self-organizing criticality. This makes the idea of dissipative systems potentially useful in to trying to understand homeland security threats in terms of entropy and open systems. There are significant limitations to this approach, however. Bertalanffy claims that in GST, isomorphisms are indispensable for understanding subjects that cannot be analyzed well quantitatively, such as “biological, behavioral, and social sciences.”⁴⁹ He also notes that these topics cannot be modeled well mathematically. Social entropy theory and living systems theory also have difficulties describing dissipative systems quantitatively. Although SET holds that the macro-sociological variables from SET can be mathematically represented by simultaneous differential equations, it has not actually been done.⁵⁰ LST has never been quantified.⁵¹

⁴⁷ Donald L. Turcotte, “Self-organized Criticality,” *Reports on Progress in Physics* (1999): 1416–1417.

⁴⁸ Tessaleno C. Devezas and George George Modelski, “2011 World System Processes: An Evolutionary Approach. World System History,” in *Encyclopedia of Life Support Systems* (Oxford: Eolss 2011) as cited in George Modelski, “Kondratieff (K-) Waves in the Modern World System,” in *Kondratieff Waves: Dimensions and Prospects at the Dawn of the 21st Century*, ed. Leonid Grinin, Tessaleno Devezas, and Andrey Korotayev (65–76) (Volgograd: Uchitel Publishing House, 2012).

⁴⁹ Ludwig von Bertalanffy, *General System Theory* (New York: George Braziller, 1968), 34.

⁵⁰ Bailey, *Social Entropy Theory*, 266.

⁵¹ Bailey, “Living Systems Theory and Social Entropy Theory,” 296.

Attempts to mathematically apply the concept of dissipative systems to a wide variety of subjects have met with similar frustrations. Social systems and organizations,⁵² organizational transformation,⁵³ economic and social development,⁵⁴ and ecosystems⁵⁵ have all been modeled as dissipative systems but only on a descriptive level. The idea of a system undergoing an entropy process of increasing disorder has been applied to organizations, biological, economic, and societal systems⁵⁶ but still only descriptively. One explanation for the problems in dealing with this subject matter quantitatively is that the idea of dissipative systems as “based upon probabilistic behavior among many system parts rather than predictable change in one of a few elements.”⁵⁷ Many systems are just too complicated to model this way. Therefore, this paper will apply the idea of dissipative systems to the subject of homeland security on a descriptive level.

E. MEASURES OF ENTROPY AS A SYSTEM PROPERTY OF THE HOMELAND SECURITY ENVIRONMENT

The concept of entropy and dissipative systems and systems approaches based on dissipative systems may be useful to describe the factors contributing to homeland security threats. In order to meaningfully apply these ideas to entities and processes in the real world, we will need a way of relating the idea of entropy to specific aspects of social, economic, and environmental systems on the level of specific human activities and on the system level. Now, we will examine the use of money as an entropy marker on micro and macro levels.

⁵² Michael K. Mathews, Michael C. White, and Rebecca G. Long, “Why Study the Complexity Sciences in the Social Sciences?” *Human Relations* 52, no. 439 (1999): 439–462.

⁵³ Richard Leifer, “Understanding Organizational Transformation Using a Dissipative Structure Model,” *Human Relations* 42, no. 10 (1989): 899–916.

⁵⁴ Robert Beil, “The Interplay between Social and Environmental Degradation in the Development of the International Political Economy,” *Journal of World-Systems Research* 12, no. 1 (2006): 113–114.

⁵⁵ James J. Kay, “Ecosystems as Self-organizing Hierarchy Open Systems: Narratives and the Second Law of Thermodynamics,” in *Handbook of Ecosystem Theories and Management*, ed. Sven Eric Jorgensen and Felix Muller (135–160) (Boca Raton, FL: CRC Press -Lewis Publishers, 2000), 150.

⁵⁶ Gary Gemmill and Charles Smith, “A Dissipative Structure Model of Organization Transformation,” *Human Relations*, 38 (1985): 755.

⁵⁷ *Ibid.*, 765.

1. Money as an Entropy Marker

G. A. Bailey, an accounting expert, worked with Kenneth Bailey of SET and James Grier Miller, who created LST, to develop an approach to using money as a marker used to measure entropy transfers within and among organizations. As we recall from SET and LST, social systems overcome the entropy by importing matter, energy, and information that are higher in ‘negative entropy’⁵⁸ or “negentropy” than what they produce.⁵⁹ “Negentropy” refers to the means (matter, energy, information, or combination of these things) to reverse entropy in a system. A way of looking at it is the order that the inputs bring into the system to counter entropy. Decision makers in organizations need a way of measuring the negentropy of what they produce and also the organizational entropy occurring within their systems of production.⁶⁰

Used as an entropy marker, money has a dual role, serving as both information and as a commodity.⁶¹ In exchanged-based societies, money-information markers provide measurements of societal negentropy and entropy within the production processes⁶² and measure flows of matter, energy and information among different parts of society, such as organizations.⁶³ Goods, services, and monetary assets moving within the organization⁶⁴ represent the movements of matter, energy, and information. Modern accounting systems that use double-entry methodology actually measure entropy flows to provide managerial information to decision makers.⁶⁵ Each exchange consists of two

⁵⁸ Bertalanffy credited Erwin Schrodinger with the idea of “negative entropy.” Bertalanffy, *General System Theory*, 43.

⁵⁹ Gale Alden Swanson, Kenneth D. Bailey, and James Grier Miller. “Money: A Living Systems Theory Perspective,” *Systems Research and Behavioral Science* 14, no. 1 (1997): 45–65.

⁶⁰ Ibid., 59.

⁶¹ Ibid., 55.

⁶² Ibid., 58.

⁶³ Ibid., 59.

⁶⁴ Ibid., 60.

⁶⁵ Ibid., 63.

types of transactions: the inflow and the outflow. Inflows are debits, and outflows are credits.⁶⁶ Additionally, markets determine exchange values.⁶⁷

As a result, overall entropy flows are approximated extensively in financial information.⁶⁸ Although statistics such as net income and earnings per share are not actual measures of entropy transfers, they are based on these measurements.⁶⁹ Debt represents a future flow of goods and services and, therefore, entropy.⁷⁰ Thus, the debt situation of an organization can represent future flows of entropy. If we view overall homeland security in terms of entropy flows, then the growing U.S. national debt ultimately represents a reduction in our overall long-term homeland security.

2. Social Free Energy

Earlier in this paper, we introduced the idea of thermodynamic potential. A meta-theoretical application of the idea of “potential” to the social realm is “social potential.” Social potential can be used to describe some of the statistical properties of social systems.⁷¹ Another thermodynamic concept related to entropy which has also been applied to social systems is “social free energy.” Social free energy is a representation of the amount of resources that can be extracted from a social system without significant changes in its structure, or a measure of surplus resources.⁷² The lower the social entropy, the greater the amount of social free energy that is available for use and the better adapted the social systems is to its environment.⁷³ Since social free energy is the amount of resources that are *not* used to maintain the social structure, it can be used to approximate

⁶⁶ Ibid., 59.

⁶⁷ Ibid.

⁶⁸ Ibid., 60.

⁶⁹ Ibid.

⁷⁰ Ibid., 57.

⁷¹ Josip Stephanic, Jr., Hrvoje Stefancic, Mislav Stjepan Zebec, and Kresimir Perackovic, “Approach to a Quantitative Description of Social Systems Based on Thermodynamic Formalism,” *Entropy* 2 (2000): 98.

⁷² Josip Stephanic, Jr., “Describing Social Systems Using Social Free Energy and Social Entropy,” *Kybernetes* 34, no. 5/6 (2005): 862.

⁷³ Josip Stephanic, Jr. “Social Equilivent of Free Energy,” *Interdisciplinary Description of Complex Systems* 2, no 1 (2004): 57.

resources available to build new structure or recover from an event. The greater the amount of social free energy, the greater the resilience and ability to recover from a catastrophe, and the greater the amount of resources available to counter homeland security threats. In other words, social free energy can be used as a proxy measure for overall the “homeland security potential” of a social system. Combining the ideas that money is an entropy marker and social free energy is a measure of overall system entropy (and also homeland security potential) we have a tool for making rough estimates of how different expenditures can affect our nation’s homeland security potential.

By using money as an entropy marker, we can ascertain whether the resources expended on homeland security actually increase homeland security. If an expenditure results in a net increase in social free energy (i.e., if the systemic cost of the problem solved is greater than the resources expended to solve it), then homeland security is enhanced. Note that many non-homeland security expenditures made to maintain our nation’s organizational structure also affect social free energy, and therefore homeland security. Expenditures such as transfer payments and policies such as trade policy, education policy, and government regulation of business, may well result a net change in social free energy, and not necessarily positive changes. As with other cases of applying thermodynamic ideas to social systems, social free energy cannot be rigorously modeled quantitatively.⁷⁴ Social free energy can be used to describe characteristics of a social system or make estimates of overall system security.

⁷⁴ Stephanic, “Describing Social Systems Using Social Free Energy and Social Entropy,” 860.

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III. METHODOLOGY FOR THE REST OF THE PAPER

This paper meta-theoretically applies the idea of dissipative systems to model processes of self-organization and entropy occurring in the world that yield actual homeland security threats.⁷⁵ A model for entropy flows due to flows of matter, energy, and information in a social, economic, and environmental unit of analysis will be synthesized and used to illustrate how entropy transfers occur within “organisms.” Next, different mechanisms for entropy transfer occurring upon different levels of a scalable social unit of analysis having economic, social, and environmental components and its environment over varying time frames will be explored. Then, the dynamics of these mechanisms will be compared to properties of dissipative systems.

Another model will be constructed and illustrate how fundamental processes of self-organization that are occurring in the world are causally linked to actual homeland security threats via intermediate processes.

Finally, homeland security will be discussed as a system property that derives from a balance between entropy and self-organization in an open system. The implications for thinking about the concept of homeland security, the government’s role in homeland security, and implications for the homeland security enterprise will be explored.

⁷⁵ DHS, *Quadrennial Homeland Security Review Executive Summary*.

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IV. FINDINGS: MODELING ENTROPY TRANSFERS AMONG ORGANISMS

In order to discuss systems, we must first define the term. Ludwig von Bertalanffy offered the following definition: “A system can be defined as a complex of interacting elements.”⁷⁶

To describe a system, we must therefore specify:

1. The system’s boundary and its properties,
2. the elements within the system’s boundaries, and...
3. how those elements interact.

Now we will examine these criteria in more detail.

A. SYSTEM BOUNDARY

Dissipative systems have open boundaries that allow the two-way transfer of matter, energy, and information. The placement of the system boundary has a major impact on the results of analysis. According to LST, social systems tend to be hierarchically ordered, with the levels being individual, group, organization, community, society (as used here, nation), and supranational system.⁷⁷ The constituents of the homeland security enterprise can correspond to any of these levels, as can the sources many homeland security threats. Therefore, to be useful for doing homeland security analysis, a model should be able to account for interactions within and among any of these different levels. In other words, it must be scalable.

B. SYSTEM ELEMENTS

The system’s elements are those located within the system boundary. We are trying to model the social, economic, and environmental factors that constitute the homeland security environment. SET has provided a list of macro sociological variables: EPILOTS (matter-energy (E), population size (P), information (I), level of living (L),

⁷⁶ von Bertalanffy, *General System Theory*, 55.

⁷⁷ Bailey, “Living Systems Theory and Social Entropy Theory,” 291.

organization (O), technology (T), and space or territory (S). SET holds that these variables are sufficient to describe any group.⁷⁸

The macro-sociological variables from SET do not correspond to standard academic disciplines, which can make research more difficult. In order to better fit academic categories, the SET variables can be regrouped as follows: First separate the macro-sociological variables into those things relating to humans (society): (information, level of living, organization, technology) and non-human: (the physical space or territory). Then further subdivide human parts by separating out the economic aspects to make: “economy.” These categories are nested. Economy is a subset of “society,” and society is a subset of the “environment.” This leaves the more standard academic categories to use for the model—*environment*, *society* and *economy*. The space outside the system is the *external environment*.

C. HOW THE ELEMENTS INTERACT

Matter, energy, and information (and things composed of these factors) flow among the constituents of the model (environment, society, and economy) and its external environment. The dynamics of these interactions are consistent with the characteristics of a dissipative system. These characteristics include:

- Entropy
- Self-organization
- feedback loops
- Multiple steady states.⁷⁹ and
- Self-organized criticality⁸⁰

We have previously mentioned the difficulties in quantitatively modeling social, economic, and environmental systems as dissipative systems, so this model will be descriptive. Figure 1 is an illustration of the model.

⁷⁸ Ibid., 297.

⁷⁹ Prigogine, Micolis, and Babloyantz, “Thermodynamics of Evolution,” 25.

⁸⁰ Bak, Tang, and Wiesenfeld, “Self-organized Criticality,” 365.

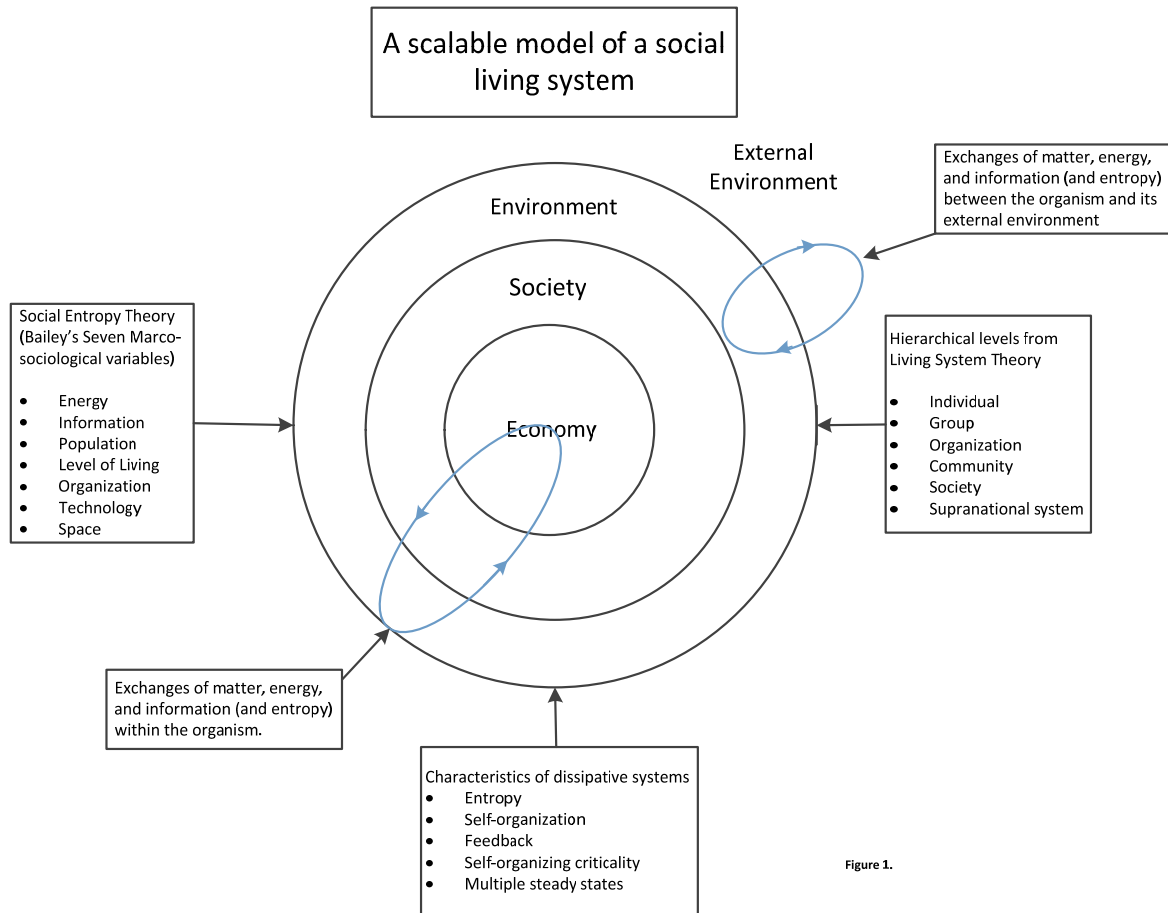


Figure 1.

Figure 1. A scalable model of a social living system

D. ENTROPY TRANSFERS AMONG LIVING SYSTEMS

Due to scarcity of inputs, living systems, or organisms at all levels compete for the inputs they need to maintain themselves.⁸¹ Some will obtain all the inputs they need and others will not. Organisms unable to obtain the negentropy they need to sustain themselves will undergo an entropy process and perhaps even die. Recall that organism maintain themselves by exporting their entropy to their environment. If an organism dies because the inputs that it needs to live were all consumed by another, fitter organism, then the fit organism can be seen as exporting its entropy not only to its environment, but

⁸¹ Living systems as defined by living system theory, including organism, group, organization, community, society, and supranational system. Miller and Miller, "Introduction: The Nature of Living Systems," 158–161.

also to the organism that died as well. A way of looking at this is that from the perspective of one organism, all other organisms are part of its external environment. Exporting entropy to the environment inhabited other organisms may indirectly export entropy to those other organisms, even killing them.

According to LST, societies are living systems.⁸² Different social systems are competing for limited inputs, and some are receiving those inputs at the expense of others. This means that economic and social competition results in net entropy transfers among competitors—even when are they not overtly hostile. For example, companies compete for resources. If one company acquires limited inputs at the expense of another, the competitor is harmed, even though there may be no direct hostility between them. The effects of the resulting entropy transfers are damaging nonetheless, even if the affected parties are cooperating on many levels.

E. THE SUBJECTIVE NATURE OF ENTROPY TRANSFERS

Because they can experience very different outcomes, different participants in an entropy transfer may view the same interaction quite differently. This makes the interpretation of entropy flows subjective. For example, the terrorist organization and budding state the Islamic State of Iraq and Syria (ISIS) sprang onto the scene in 2014, seizing territory in Syria and Iraq. From the perspective of Iraq and Syria, the conflict with ISIS represented a breakdown in the organization of these countries, or an entropy process. From the perspective of ISIS, however, the process was one of strong self-organization.

An interaction between two nations may result in enhanced homeland security for one nation and reduced homeland security for another. To be useful, an approach to understanding homeland security should be able to model the interaction from both of these perspectives. The model represents a social system within its environment. If an entropy transfer is occurring between two competing nations, this means that they are connected by a flow of matter, energy, and/or information, which implies that they are

⁸² Manuel Castells, “Materials for an Exploratory Theory of the Network Society,” *British Journal of Sociology* 51, no. 1 (2000): 5–24.

sharing a common environment. By applying the model separately with each nation being the unit of analysis, the model allows for each nation to be considered as part of the other's external environment. This means that the model allows the same flow of entropy to be modeled from the perspective of each nation, which allows a single process to be seen from both perspectives.

Nature and human living systems are hierarchically ordered,⁸³ and different hierarchical levels in society interact with each other. The model accounts for different levels of hierarchy because if one organism is nested within another, the organism that is hierarchically higher constitutes the environment of the other organism. Therefore, a transfer of entropy between a selected organism and its environment represents a transfer between that organism and the next level in the hierarchy.

The breakup of the Soviet Union provides a useful example of how the outcome of analysis depends on the hierarchical level of the unit of analysis. From the standpoint of Lithuania, Lithuania's declaration of independence from the Soviet Union in 1991 represented a process of self-organization by which Lithuania once again became an independent country. From the point of view of the Soviet Union, however, Lithuania's independence represented an entropy process by which the Soviet Union was progressively disintegrating. Viewed globally, the collapse of the Soviet Union represented the continued self-organization of a capitalist economic system as it absorbed the former Soviet Bloc.

Note that not all interactions among living systems have to create losers. For example, the cells in a body function in a cooperative way, and there is a balance of entropy among them. Analysis is required determine the actual entropy flows that occur in any given interaction.

⁸³ Miller and Miller, "Introduction: The Nature of Living Systems," 157–163.

F. CREATIVE DESTRUCTION—ENTROPY TRANSFER IN THE ECONOMY

In the 1930s, economist Joseph Schumpeter explained the force driving the development of a capitalist economy occurs, which he called “Creative Destruction.”⁸⁴ Under creative destruction, competition drives the creation of new, more efficient forms of economic organization as less efficient and effective firms are destroyed.

Firms exchange revenue to acquire the inputs of matter, energy, and information that they need to overcome entropy. A way of looking at creative destruction is the attrition of less competitive firms to more competitive ones in a struggle for customers and, ultimately, revenue. Less fit firms are unable to earn the revenue they need, undergo an entropy process, and go bankrupt, and their assets are sold off and absorbed into other organizations. Completion among firms is mediated by their environment. One way of looking at this is that the surviving firm deprives or extracts resources (revenue, and potentially, assets) from the less fit firm, which causes it to go bankrupt. Another way of looking at it is that the surviving firm exports its entropy to the dying firm. Viewed across time, creative destruction can be seen as a process of entropy transfer from a new, growing economic structure to an old, less fit, and dying one, leading to its eventual replacement. Generally, creative destruction is seen as a positive dynamic by which assets are absorbed by more effective firms and thereby allocated to more productive use.

The process of creative destruction does not necessarily have to occur evenly across different countries. In a world connected by increasingly globalized markets, the results of competition can be distributed unevenly across nations, with the creation of new industries occurring in one country and the destruction of old industries in another. If innovations occur in bunches, they can launch technological revolutions that create new industrial or commercial sectors.⁸⁵ History shows that these new sectors are typically grouped in a single country, at least initially.⁸⁶ This country can become the lead

⁸⁴ Joseph A. Schumpeter, *Capitalism, Socialism and Democracy* (New York: Harper, 1975) (originally published, 1942), 83.

⁸⁵ Modelski, “Kondratieff (K-) Waves in the Modern World System,” 66–67.

⁸⁶ Ibid.

economy in the world and a main determinant of global order.⁸⁷ The U.S. is currently the lead global power.⁸⁸ As a center of self-organization going in on the world, the U.S. has the capacity to export entropy. This has positive implications for national and homeland security. Loss of this lead position to another nation would mean that the U.S. would no longer be the focus of global organization. In turn, this would mean that the new lead nation would be the focus of global organization and better able than we to export entropy, meaning that we would then be in a position to receive entropy transfers from the new lead nation. Another way of looking at this is that our ability to shape the world in ways favorable to our interests would be reduced, which would ultimately negatively impact our homeland security potential.

G. ECONOMIC ENTROPY TRANSFERS BETWEEN THE U.S. AND CHINA

China is emerging as the primary economic competitor for the U.S. The nature of the economic competition at this stage is peaceful and voluntary, but the recent results are not equal for both countries. The next section will look at the impact of China's economic rise on the U.S. in the context of entropy transfers and creative destruction.

China is a striking example of how system openness can facilitate self-organization. A new era in Chinese economic history began in December 1978 when the communist government decided on a policy of *Gaige Kaifang*, or “reform and opening up.”⁸⁹ Since then, China's real per capita gross domestic product (GDP) has grown at an average rate of over eight percent a year.⁹⁰ This unprecedented economic transformation has been driven mainly by an increase in productivity growth that has been underpinned by “gradual and persistent institutional change” and policy reforms that have “reduced distortions and increased economic incentives” for productivity growth.⁹¹

⁸⁷ George Modelski, “The Long Cycle of Global Politics and the Nation-State,” *Comparative Studies in Society and History* 20, no. 2 (1978): 216.

⁸⁸ *Ibid.*, 214.

⁸⁹ Zhu Xiaodong, “Understanding China's Growth: Past, Present, and Future,” *Journal of Economic Perspectives* 26, no. 4 (2012): 110.

⁹⁰ *Ibid.*, 103.

⁹¹ *Ibid.*, 103–104.

The United States has been running a significant trade deficit with China for decades. The deficit has grown from approximately \$100 billion in 2002 to approximately \$350 billion in 2014.⁹² The trade deficit with China comprises the vast majority of America's overall trade deficit.

Furthermore, a significant part of China's manufacturing growth has come at the expense of U.S. manufacturing. Between 1991 and 2007, U.S. imports from China have increased by 1,156 percent.⁹³ In the U.S., rising imports have caused higher unemployment, lower labor force participation rates, and reduced wages in local labor markets where import-competing manufacturing industries are located.⁹⁴ Labor markets experiencing direct competition from Chinese manufacturing are not the only ones that have been affected, however. "Import shocks" trigger a decline in wages outside of the manufacturing sector with reductions in employment and wage levels leading to a sharp drop in household income.⁹⁵ According to one estimate is that between 2001 and 2007, the increase in the U.S. trade deficit with China eliminated 2.7 million jobs and over 2.1 million were in manufacturing.⁹⁶ Between 1999 and 2013, real median household income in the U.S. went from \$56,849 to \$51,993.⁹⁷

Negative economic trends such as these can have significant implications for homeland security if the changes in income result in some kind of civil disturbance. For example, the recent violent protests in Ferguson Missouri have been associated with this community's deteriorating economic situation.⁹⁸ Similar protests have spread to other

⁹² Wayne Morrison, *China-U.S. Trade Issues* (Washington, DC: Congressional Research Service, 2014), 4.

⁹³ David Autor, David Dorn, and Gordon Hanson, "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review* 103, no. 6 (2013): 2131.

⁹⁴ *Ibid.*, 2159.

⁹⁵ *Ibid.*, 2158.

⁹⁶ Robert E. Scott, *Trading Away the Manufacturing Advantage* (Washington, DC: Economic Policy Institute, 2013), 1.

⁹⁷ "Real Median Household Income in the United States," Federal Reserve Bank of St. Louis, Economic Data, September 30, 2014, accessed February 7, 2015, <http://research.stlouisfed.org/fred2/series/MEHOINUSA672N>.

⁹⁸ Elizabeth Kneebone, "Ferguson, Mo. Emblematic of Growing Suburban Poverty," Brookings, August 15, 2014, accessed February 9, 2015, <http://www.brookings.edu/blogs/the-avenue/posts/2014/08/15-ferguson-suburban-poverty>, 1–2.

cities. If such protests escalated further into a general civil disturbance, it would be a significant homeland security concern. While many factors contribute to this overall trend, Chinese economic competition certainly has played a significant part. Lower wages and increased unemployment have also contributed to rising transfer payments through federal and state programs⁹⁹ which, in turn have an impact of budgets and, ultimately, the national debt.

U.S. federal debt has grown precipitously in recent years. Between 2000 and 2014, the U.S. federal debt has grown from \$5.6 trillion to \$17.8 trillion, with \$9.3 trillion accumulating since 2006.¹⁰⁰ The political and economic causes of the federal debt are complex. Tax cuts, the financial crisis of 2007, and demographic trends are partially to blame for this trend, but job losses due to Chinese competition also have played a significant part. Regardless of the reason for the growth in debt, from the perspective of money as an entropy marker, the large amount of borrowing represents an importation of negentropy that will have to be paid back in the future. In other words, the outflows of money to service the debt would represent outflows of the means to self-organization. From another perspective, the outflows of money would represent an inflow of entropy. From the standpoint of social free energy, the debt represents a reduction in the resources available for preserving the current structure of society. If we view social free energy as a rough proxy for overall homeland security as a system property, then the potential for the U.S. to maintain its overall homeland security is being reduced by the accumulating debt.

Trade is not a zero sum game. Trade is voluntary, and both trading partners see themselves as better off due to a specific transaction. Over time, however, trade can result in processes that affect the trading partners differently. Viewing economic relations between the U.S. and China from the standpoint of self-organization and entropy, China has experienced a strong dynamic of self-organization coinciding with its continuing rise as a manufacturing power. The United States, on the other hand, has experienced a major decline in its manufacturing sector due in part to Chinese competition. (Of course

⁹⁹ Shaun Roache, *China's Impact on World Commodity Markets* (working paper, Washington, DC: International Monetary Fund, 2012), 2159.

¹⁰⁰ U.S. Treasury. "Historical Debt Outstanding," Treasury Direct, November 10, 2014, accessed February 9, 2015, http://www.treasurydirect.gov/govt/reports/pd/histdebt/histdebt_histo5.htm.

competition from other countries, and other factors also have played a part in this trend.) On balance, however, it is valid to conclude that Chinese self-organization has resulted in a decline, or organizational entropy, process in the U.S. One way of looking at this is as a process of creative destruction. More of the creation occurred in China, and more the destruction occurred in the U.S. Another way of looking at it would be that China transferred entropy to the U.S. That this transfer of entropy occurred via processes that were completely voluntary and during a period of peace and cooperation between the U.S. and China does not change the fact that in relative terms, and even some absolute terms, the U.S. has suffered damage, and our homeland security potential has been reduced.

The case of the U.S. and China is an example of economic entropy transfer among nations by peaceful, voluntary means. Entropy transfers could also occur through strategic, hostile, and even violent means. In other words, organisms could take action specifically designed to deprive a rival of needed inputs, or simply overtly and violently attack the rival. All of these kinds of interaction can be understood in the context of entropy transfer. In other words, entropy transfer can be used to model warfare occurring at different levels and varying degrees of intensity.

V. FINDINGS: THE SELF-ORGANIZING DYNAMIC OF GLOBALIZATION

We see globalization—growing interconnectedness reflected in the expanded flows of information, technology, capital, goods, services, and people throughout the world—as an overarching ‘mega-trend,’ a force so ubiquitous that it will substantially shape all the major trends in the world of 2020.

National Intelligence Council¹⁰¹

As the succession of rising and falling nations throughout history illustrates, threats to homeland security are nothing new. All nations face homeland security threats of one form or another of varying intensity and always have, even as the world changes over time. One of the main features of global development over the last quarter century or so has been globalization. Like homeland security, globalization can mean different things to different people in different contexts. Still, we need a definition to work with. For this paper, we will use the following definition:

Globalization is a process of interaction and integration among people, companies, and governments of different nations, a process driven by international trade and investment and aided by information technology. The process has effects on the environment, on culture, on political systems, on economic development and prosperity, and on the human physical well-being in societies around the world.¹⁰²

Because globalization is such a significant feature of the world today, it will have a major impact on the processes that give rise to homeland security threats. This is not meant to imply that without globalization the world, and our homeland, would be free from homeland security threats or even more secure than it is now. Globalization brings many benefits. These benefits can work to reduce or mitigate homeland security threats.

¹⁰¹ National Intelligence Council, *Mapping the Global Future* (Pittsburgh: Governmental Printing Office, 2004), http://www.dni.gov/files/documents/Global%20Trends_Mapping%20the%20Global%20Future%202020%20Project.pdf, 10.

¹⁰² “Globalization,” Leven Institute, 2015, <http://www.globalization101.org/what-is-globalization/>.

However, since this paper is linking current global processes to homeland security threats, globalization will be analyzed in terms of its links to homeland security threats.

Other trends that pre-date the current phase of globalization that has taken root since WWII, such as the advance of technology, economic growth, and population growth, also have a major impact on homeland security. The effects of these trends on homeland security will also be considered.

A. BUILDING THE TREND MAP

Earlier parts of this paper have explained that the concept of dissipative systems has been applied to many different kinds of systems and is a basis of the approaches to systems presented in this paper: general system theory, social entropy theory, and living system theory.¹⁰³ Also, recall that social entropy theory¹⁰⁴ and living system theory¹⁰⁵ have never been quantified and that general system theory holds that many “biological, behavioral, and social sciences” cannot be analyzed well quantitatively.¹⁰⁶

This creates something of a conundrum. On one hand, most of the social, economic, and environmental factors that give rise to homeland security threats can be understood in terms of SET, LST, GST and are, by definition, dissipative systems or components of dissipative systems. At the same time, very few of the factors that combine to yield homeland security threats can be directly modeled mathematically as dissipative systems are in the physical sciences. Homeland security appears to be emerging as (yet another) academic discipline; however, the number of topics that can affect homeland security is seemingly endless. Furthermore, the complex and continually changing processes that are giving rise to homeland security threats cannot be understood in terms of the study of homeland security. Rather, at a holistic level, the causes of homeland security threats must be understood within the context the many academic

¹⁰³ Bailey, *Social Entropy Theory*, 81; Bailey, “Living Systems Theory and Social Entropy Theory,” 299; von Bertalanffy, “The Theory of Open Systems in Physics and Biology,” 26.

¹⁰⁴ Bailey, *Social Entropy Theory*, 266.

¹⁰⁵ Bailey, “Living Systems Theory and Social Entropy Theory,” 296.

¹⁰⁶ von Bertalanffy, *General System Theory*, 34.

disciplines that apply to the economic, social, and environmental topics that describe the environment that launches homeland security threats.

This matter is complicated by the tendency of disciplines to become increasingly specialized and to operate within different paradigms based on different simplifying assumptions and with different concepts of what constitutes rigor and proof. Indeed, even the systems approaches mentioned in this paper, which are intended to provide a unifying framework for integrating different disciplines, are diverging. Furthermore, many of the simplifying assumptions used in different academic disciplines, such as isolating subjects to be studied from aspects of their environment, assuming equilibrium conditions, assuming “all other things to be equal,” or artificially limiting the number of potential causal factors in order to facilitate quantitative modeling, directly contradict, and thereby obscure, the characteristics of dissipative systems. In short, the processes that give rise to homeland security threats may be the result of the dynamics of dissipative systems, but cannot be directly modeled as such.

Since we have already determined that much of the subject matter related to homeland security cannot be modeled quantitatively, it will have to be modeled descriptively. How can these disparate disciplines and paradigms be synthesized to represent the factors spawning homeland security threats as a single, integrated dissipative system?

First of all, we need a way to integrate ideas and information that originate from various disciplines. As mentioned earlier, different disciplines operate in different paradigms. One thing that they usually have in common, however, is that they seek to determine *causal relationships* among the different factors or variables that they are studying. Further, there are frequently overlaps among the claims of causal relationships among different disciplines, and among different sources within the same discipline. If these causal overlaps are connected, or linked together, a causal chain can be constructed that integrates the conclusions of different academic disciplines. Causal relationships that persist over time can be seen as *trends*. This approach is somewhat subjective, but if the correct causes are chosen, the result can be valid and provide useful insight into the root causes of homeland security threats.

Next, recall from GST the notion of “isomorphs,” or similar structures that are found in different disciplines. If the global environment that is spawning homeland security threats actually is a dissipative system, then we should expect to find isomorphs of the characteristics of dissipative systems in literature that pertains to homeland security threats. The text will explain how the characteristics of a dissipative system—entropy, self-organization, feedback, self-organized criticality, and multiple steady states are incorporated in the causal model, or trend map, that follows.

In order to construct the diagram within the space of this thesis and have it fit on a single sheet of paper, it will be necessary to distill complex, subtle, and nuanced subject matter down to some general, approximate relationships. This is not meant to say that the relationships among the components of the diagram are all simply and directly causal, to deny the complexity of the issues involved, or imply that what is presented is a complete account of the dynamics at play. It is not and cannot be within the confines of this paper. The purpose is to illustrate how applying the concept of entropy in open systems and associated systems concepts can integrate the widely diverse subject matter related to the causes of homeland security threats into an understandable and coherent whole. Hopefully, a more coherent understanding of the causes of homeland security threats can help to inform more coherent and effective homeland security strategy and policy.

As mentioned previously, causal relationships that persist, and even intensify over time, will be called trends. A mechanism by these trends can persist and intensify is by feedback, or, as expressed in terms of causality, circular and cumulative causality.

B. THREE “MEGA TRENDS”: POPULATION GROWTH, ADVANCE IN TECHNOLOGY AND ECONOMIC GROWTH

When applying the principles of LST, SET, and GST to origins of homeland security threats, we are, for the most part, dealing social systems. In order to make sure that all the important constituents of a social system are being accounted for, we can start with the macro-sociological variables from social entropy theory, which are represented by energy, population, information, level of living, organization, technology, and space

(or territory) (EIPLOTS).¹⁰⁷ We will combine and reduce the number of variables in order to simplify things. This is done in the following way:

- “Space” will define the physical environment and will mainly be dealt with in terms of environmental issues.
- “Organization” will be dealt with in the context of economic and social structures mentioned in the paper.
- The “level of living” is determined by the economy. The state of the economy is determined by the rest of the variables, since they are all “related reciprocally or in a state of interdependence or mutual causation,”¹⁰⁸ which is similar to “circular causation” from “circular and cumulative causality” explained earlier.
- Matter, energy, and information flow throughout.
- This leaves us with “population” and “technology,” which we can match with the “economy” and investigate how changes in these variables interrelate with the others.

All the macro-sociological variables are accounted for. Now we can examine how the variables interrelate not only in the present, but how they interrelate over time to form trends (via cumulative causality). The trends we will start with are economic growth, the increase population, and advance of technology. Information from the literature will be synthesized to show the dynamics of these trends. The importance of these variables over a long time frame makes these trends “megatrends.”

What follows is a narrative organized around the construction of a diagram linking a wide variety of trends and processes to illustrate how homeland security threats can be causally linked to fundamental processes of self-organization occurring in the world. The diagram is not proposing new theories or facts. It is taking theories and facts that already exist in the literature and synthesizing them to tell a story about how the dynamics of self-organization in the world in can give rise to dynamics of disorder. Some of this disorder is manifested as homeland security threats.

The factors that are shown in the map are the topics labeled in bold font in the following text. The short summaries in the text boxes summarize the preceding text and

¹⁰⁷ Bailey, *Social Entropy Theory*, 99–100.

¹⁰⁸ Ibid., 99.

to convey the causal direction of the trends. The bolded wording in the in the text boxes is the same wording that is used in the trend map diagram. The arrows in the diagram show the direction of causality. Now, we turn to the task of understanding major processes of self-organization occurring in the world today.

C. POPULATION GROWTH

Between 1960 and 2013, Earth's population more than doubled from three billion to 7.2 billion people.¹⁰⁹ In the same period, child mortality rates plummeted, life expectancy increased, and people were healthier and better nourished on average than at any time in history.¹¹⁰ Currently, the increase in population does not appear to be a prerequisite for a continuation of economic globalization and advance in technology, as economically developed countries are expected to have much slower growth rates in population than in developing countries in the near future.¹¹¹ Even so, the global increase in population is expected to continue well into the next century, increasing from approximately six billion now to 9.6 billion in 2100, with most of the population increase occurring in developing countries.¹¹² Population growth does increase economic potential and growth as the number of available workers increases.

1. Increasing Resource Use

Population growth leads to more demands for resources. While the relationship between population size and environmental change is complex, as the global population grows, it places more strain on arable land, potable water, forests, fisheries, and other resources. In other words, resource utilization increases as the global population grows.¹¹³ Increased resource use can also lead to resource depletion and environmental

¹⁰⁹ United Nations Fund for Population Activities [UNFPA], "Linking Popululation, Poverty, and Development," accessed October 28, 2013, <http://www.unfpa.org/pds/trends.htm>, 1–2.

¹¹⁰ Lori M. Hunter, *Population and Environment: A Complex Relationship* (Santa Monica, CA: RAND, 2012), accessed November 17, 2013, http://www.rand.org/pubs/research_briefs/RB5045/index1.html, 1.

¹¹¹ UNFPA, "Linking Popululation, Poverty, and Development," 1–2.

¹¹² *Ibid.*, 1.

¹¹³ Hunter, *Population and Environment*, 3.

degradation. For example, a reduction the amount of farm land due to overuse is causing concern about the ability to continue to produce adequate food for the growing global population and is causing an intensification of the way land is used.¹¹⁴ Increased use of a finite amount of available resources can also lead to increased competition for these resources, which can have major homeland security implications.

Conventional warfare is mainly a national security issue, and for this reason is not a focus of this paper. However, warfare does have many significant homeland security implications. Natural resources have played a conspicuous role in the history of armed conflicts¹¹⁵ as wars are often fought over natural resources. Therefore, the depletion of natural resources can impact the likelihood of war.¹¹⁶

The availability of any resource is thus not in itself a predictive indicator of conflict. The interests affected by the availability, need and desire for the resources, and the forces shaping the “political economy of any resource” can interact in such a way as to lead to violent conflict.¹¹⁷ As natural resources deplete, and the Earth’s climate becomes less stable, the world’s nations will likely compete more intensively for access to fossil fuels, minerals, agricultural land, and water, and this competition could result in open conflict. Warfare would result in an intensification of homeland security threats through many of the processes detailed in this paper.

2. Surplus Labor

For the purposes of this paper, “surplus labor” describes a situation where population growth exceeds the ability of the economy to provide satisfactory employment for the population. In many developing countries, population growth outstrips the availability of employment. This is especially true of the rural sector. Rural poverty

¹¹⁴ Ibid.

¹¹⁵ Philippe Le Billon, “The Political Ecology of War: Natural Resources and Armed Conflicts,” *Political Geography* 20 (2001): 562.

¹¹⁶ “Natural Resource Depletion and the Changing Geopolitical Landscape,” Post Carbon Institute, January 19, 2012, accessed November 3, 2013, <http://oilprice.com/Geopolitics/International/Natural-Resource-Depletion-and-the-Changing-Geopolitical-Landscape.html>.

¹¹⁷ Le Billon, “The Political Ecology of War,” 53–54.

causes migration to cities where the prospects are somewhat better; however, the net result of this migration is often that there are not sufficient jobs in cities either, leading to the development of sprawling slums. The resulting surplus of labor in the cities suppresses wages there as well. In other words, there is a situation of “supply push” as opposed to “demand pull” that is causing the migration.¹¹⁸ Surplus labor can cause downward wage pressure, growing income inequality, and human migration, as will be detailed later in this paper.

Population growth leads to increased resource use and can lead to surplus labor.

D. ADVANCE IN TECHNOLOGY

Greater populations and economic growth tends to increase the resources available for making technological advances. The spread of technology by legitimate means of the travel, trade, and informational linkages has been strengthened by globalization. Global economic activities result in the spread of economically relevant information and technology.¹¹⁹ Two important factors that appear to be driving this global integration are technological improvements, especially regarding transportation and communications, and reforms that result in very substantial reductions in barriers to trade.¹²⁰

1. Lower Communication and Computing Costs

Continuing improvements in information technology (communications and computing) and transportation appear to be fundamental factors driving global integration. The increasing use of computers contributes broadly to productivity at the firm level. Additionally, because computing is a “general use technology,” it appears to

¹¹⁸ Michael Todaro, “A Model of Labor Migration and Urban Unemployment in Less Developed Countries,” *The American Economic Review* 59, no. 1 (1969): 138–148.

¹¹⁹ Michael Mussa, “Factors Driving Global Economic Integration,” presented at Global Opportunities and Challenges, Jackson Hole, WY, August 2000, <http://www.imf.org/external/np/speeches/2000/082500.HTM#interact>, 24.

¹²⁰ *Ibid.*, 13.

that computers are part of a larger system of technological and organizational changes that is occurring over time.¹²¹

The costs of communicating voice, text, and data have dropped enormously, and are continuing to drop rapidly due to rapid improvements in technology. These improvements have reduced the costs of practically all forms of financial business.¹²² Reductions in the costs for storing, accessing, analyzing, and communicating information are not only reducing the costs of previously existing forms of financial services, but they also permit the creation of new, tradable products and services, such as financial derivatives, which would have been too expensive to produce with older technologies.¹²³ Another important effect of improvements in communications is the ability to separate production and distribute it across different nations, which had not been possible earlier.¹²⁴ There will be more on this topic when we deal with “network society.”

2. Improved Transportation

In the last 50 years, there have been dramatic improvements in various modes of transportation, resulting in lower shipping costs. Ocean shipping costs have fallen by a factor of four or five.¹²⁵ The most dramatic improvements have been in the area of air cargo, which has enabled the development of a variety international markets and contributed to innovations in production, such as just in time production.¹²⁶ Ocean shipping costs and land transportation costs (trucking and rail) have clearly declined in the last century, but by proportionately much less than air cargo.¹²⁷ Falling transportation costs have incited and facilitated the development of international trade, and lower cost of communication between buyers and sellers in different countries also facilitates

¹²¹ Erik Brynjolfsson and Lorin Hitt, *Computing Productivity: Firm-Level Evidence* (Cambridge, MA, 2000), 25.

¹²² Mussa, “Factors Driving Global Economic Integration,” 12.

¹²³ *Ibid.*, 12, 15.

¹²⁴ *Ibid.*, 12.

¹²⁵ *Ibid.*

¹²⁶ *Ibid.*

¹²⁷ *Ibid.*

trade.¹²⁸ Also, the influence of foreign direct investment is compounded by trade, and therefore trade and investment are closely intertwined in a global system that information technology has helped to create.¹²⁹

3. Diffusion of Technology

Economic integration has promoted the transfer of technology. The rapidly rising level of economic integration in the late twentieth century, fostered by advances in transportation as well as in information and communication technology, has shifted the focus of technological change from a domestic focus to an international one.¹³⁰ Trade can help to establish and sustain communication channels that stimulate cross-border learning of production methods, product design, organizational methods, consumer preferences, and market conditions.¹³¹ Also, foreign direct investment (FDI) often involves the transfer of knowledge from one country to another, making it a potentially important vehicle for international technology diffusion.¹³² Another means of technology transfer is the transfer of specialized and advanced intermediate products.¹³³

At the level of the firm, new technical information is usually brought into the firm by a few individuals, who have more extensive contact than others do with colleagues outside the firm or with technical literature, or both.¹³⁴ The increase in the mobility of people has facilitated their ability to transfer knowledge.

Advance in technology leads to improved transportation, lower communication and computing costs, and diffusion of technology.

¹²⁸ Jeffrey James, "Information Technology, Cumulative Causation and Patterns of Globalization in the Third World," *Review of International Political Economy* 8, no. 1 (2001): 150.

¹²⁹ *Ibid.*, 158.

¹³⁰ Wolfgang Keller, *International Technology Diffusion* (working paper, National Bureau of Economic Research, Cambridge, MA, 2001), 3.

¹³¹ *Ibid.*, 6.

¹³² *Ibid.*, 26.

¹³³ *Ibid.*, 6.

¹³⁴ James M. Utterback, "Innovation in Industry and the Diffusion of Technology," *Science* 183 no. 4125 (1974): 623.

E. ECONOMIC GROWTH

Economic growth since WWII has been impressive. Over the last five decades real world GDP has risen at more than a four percent annual rate with real GDP in developing countries, as a group, growing in per capita terms at about the same pace as industrial countries.¹³⁵ Real living standards have risen on average by about three-fold in half a century. During this period of rapid growth, world trade in goods and services has expanded at nearly double the pace of world GDP.¹³⁶ As mentioned earlier, population growth, economic growth, and the advance of technology have been mutually reinforcing (circularly causal). For example, economic growth and the advance in technology have facilitated the increase in population through the cultivation of more food, improvements in sanitation and medical technology, and improvements in the standard of living in many countries.¹³⁷ Population growth coupled with advancing technology creates conditions for economic growth. The mega-trends are summarized in the text box below:

Population growth, economic growth, and the advance in technology are mega-trends linked by feedback, have been progressing for a long time, and are expected to continue into the future, graphically illustrated in Figure 2.

Figure 2 can be understood as an illustration of how, as according to SET, the variables are “related reciprocally or in a state of interdependence or mutual causation,”¹³⁸ or in terms of circular causation where the interdependencies between the major factors interlink in the determination of major processes.¹³⁹ Then, over time, the causal linkages between the variables will begin to affect each other through positive feedback, or, in other words, through “cumulative causation.”¹⁴⁰

¹³⁵ Mussa, “Factors Driving Global Economic Integration,” 11.

¹³⁶ Ibid.

¹³⁷ Carolyn Kinder, “The Population Explosion: Causes and Consequences 2013,” Yale New Haven Teachers Institute, accessed November 12, 2013, <http://www.yale.edu/ynhti/curriculum/units/1998/7/98.07.02.x.html>, 2–4.

¹³⁸ Bailey, *Social Entropy Theory*, 99.

¹³⁹ O’Hara, “Principle of Curcular and Cumulative Causation,” 375–376.

¹⁴⁰ Ibid.

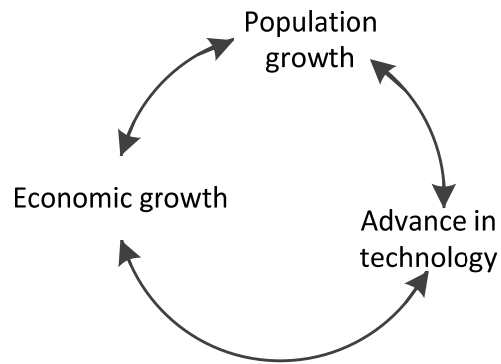


Figure 2.

Figure 2. Megatrends with feedback

The same dynamic showing more detail incorporating the summary information from earlier text boxes is shown in Figure 3.

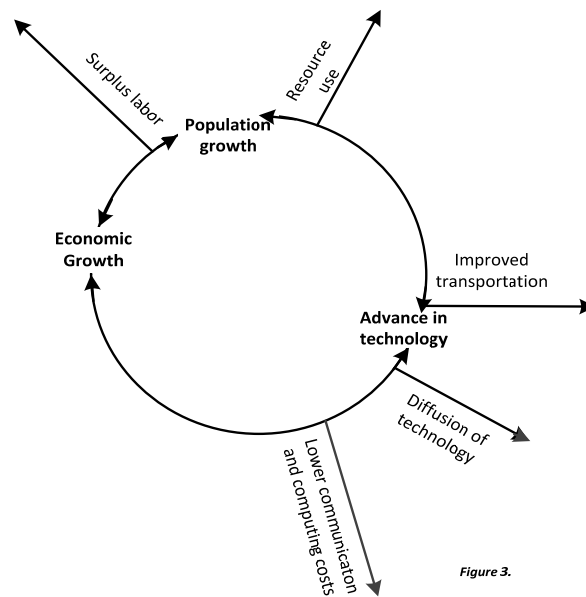


Figure 3.

Figure 3. Megatrends with more detail

F. ECONOMIC GLOBALIZATION

A characteristic feature and driver of current economic growth and development since WWII is globalization. Economic globalism, or globalization, is a trend of growing economic and financial interdependence among countries resulting from the integration of trade, finance, people, and ideas into a global marketplace. International trade and cross border investment are main elements of this integration.¹⁴¹ A trend that is occurring within these trends is the rise of the network society.

1. Network Society

Network society is a new technological paradigm¹⁴² centered on information and communications technology that is fostering globalization. Networks, through competition, “gradually eliminate other organization forms, rooted in a different social logic,”¹⁴³ fundamentally changing the character of the world economy. By linking together things that have value (people, territories, resources) anywhere on the planet through various networks, information technology is giving rise to a new form of economic organization, the network enterprise.¹⁴⁴ A new form of production organization, the business project, is also emerging.¹⁴⁵ Larger corporations are behaving more like decentralized networks, while smaller firms are connecting to each other to form networks. Networks are able to distribute their core and strategic activities by connecting assets located anywhere in the world.¹⁴⁶ They use information technology to “enhance and accelerate the production of knowledge and information,”¹⁴⁷ yielding improvement in productivity in a self-expanding, virtuous cycle¹⁴⁸ (circular and cumulative causality, once again).

¹⁴¹ World Bank, *Globalization and International Trade*, 2000, accessed November 14, 2013, http://www.worldbank.org/depweb/beyond/beyondco/beg_12.pdf, 66.

¹⁴² Castells, “Materials for an Exploratory Theory of the Network Society,” 9.

¹⁴³ *Ibid.*, 16.

¹⁴⁴ *Ibid.*, 10.

¹⁴⁵ *Ibid.*, 10–11.

¹⁴⁶ *Ibid.*, 10.

¹⁴⁷ *Ibid.*

¹⁴⁸ *Ibid.*

The development of a globalized network society has significant implications for homeland security. The role of the state is undergoing dramatic transformation due to globalized flows of wealth and communication, and the sovereignty of the state is being called into question.¹⁴⁹ At the same time, alternate media and “scandal politics” are undermining the legitimacy of the state.¹⁵⁰ Castells summarizes this new situation by noting, “while there are still power relationships in society, bypassing of centres by flows of information circulation in networks creates a new, fundamental hierarchy: the power of flows takes precedence over the flows of power.”¹⁵¹ The “power of flows” refers to the traditional government hierarchy. In the U.S., homeland security is considered to be predominantly a function the federal government, particularly DHS. A weakening of the power and legitimacy of the federal government negatively impacts DHS. “Flows of power” refers to the power conferred on networks due to their flexibility and adaptability. Networks provide actors who would harm the U.S. or engage in nefarious activities with new capabilities with which to challenge the U.S. government and jeopardize homeland security.

G. THE PERCEPTION OF THE BENEFITS OF GLOBALIZATION

The perception of the benefits of globalization has been a main motivator for changes that have promoted globalization. Social structure of accumulation (SSA) theory provides a way of looking at the social and political context of these perceptions. SSA theory seeks to explain the long waves of innovation and economic growth by focusing on the institutional arrangements that help to sustain long economic upswings.¹⁵² These institutions can be thought of in a narrow sense as organizations (like universities or the World Bank) or in a broader sense as made up of customs, habits and expectations. They are typically country or culture-specific.¹⁵³ A broad social and political accord coupled

¹⁴⁹ Ibid., 14.

¹⁵⁰ Ibid.

¹⁵¹ Ibid., 20.

¹⁵² Victor Lippit, “Social Structure of Accumulation Theory,” presented at Growth and Crises: Social Structure of Accumulation Theory and Analysis, National University of Ireland, Galway, Ireland, November 2006, 2–3.

¹⁵³ Ibid., 2.

with complimentary institutional framework incents the investment needed to launch and sustain growth.

Perceptions of the positive results of globalization from the perspective of a SSA have incented the development of the theoretical and institutional basis of globalization. As trade liberalization has opened protected markets of major industrialized countries to imports, competitive pressures caused corporations to seek deregulation in order to compete.¹⁵⁴ This new ideology of free trade and deregulation, “neoliberalism,” is based more on the global dimension than the nation-state, and some suggest that the term “global neoliberalism” best describes the contemporary SSA.¹⁵⁵ The “two aspects of the contemporary era—globalization and neoliberalism”— can be seen as being interconnected,¹⁵⁶ with neoliberalism being a coherent, multi-leveled entity whose core features include political-economic institutions, policies, theories, and ideology which therefore qualifies as an SSA.¹⁵⁷ Castells sees the restructuring of capitalism around deregulation and a “liberalization ideology” and the development of new and flexible information technologies as giving rise to a new globalized network society.¹⁵⁸

The social structure of accumulation and network society approaches have different conceptual foundations but come to some similar conclusions about conditions spawning globalization. Both see technological, social, and economic forces combining to create a new, globalized market underpinned by new, global linkages, institutions, and ideologies, and new systems of production forming a positive feedback loop in a manner of circular and cumulative causation.

There are objective reasons to believe in the benefits of neoliberalism. As mentioned earlier, economic growth since WWII has been strong. Benefits of trade

¹⁵⁴ David M. Kotz and Terrence McDonough, “Global Neoliberalism and the Contemporary Social Structure of Accumulation,” in *Contemporary Capitalism and its Crises: Social Structure of Accumulation Theory for the Twenty-First Century*, ed. Terrence McDonough, Michael Reich and David M. Kotz (1–35) (Cambridge: Cambridge University Press, 2010), 4.

¹⁵⁵ Ibid., 4.

¹⁵⁶ Ibid., 3.

¹⁵⁷ Ibid., 2.

¹⁵⁸ Castells, “Materials for an Exploratory Theory of the Network Society,” 16.

fostered by globalization have incited the development of innovations in the technology of transportation and communications that have further facilitated globalization.¹⁵⁹ In fact, the desire to reap the benefits of closer economic integration is a key reason why it is profitable to create the innovations and investments that have brought about improvements in the technology of transportation and communication that have facilitated globalization in the first place.¹⁶⁰ As mentioned earlier, the perception of the benefits of increased trade has also led to global economic institution building, which is the topic of the next section.

H. GLOBAL AND REGIONAL ECONOMIC INSTITUTION BUILDING

Global economic integration has been progressing on different levels for decades. On the global level, international trade and financial integration has been progressing through the establishment of global agreements and institutions. At the same time, regional integration has been progressing in many parts of the world. We will now examine each of these trends in more detail.

1. International Trade and Financial Integration

The perception of the benefit of free trade has motivated the development of increasingly powerful international institutions to promote free trade and administer international economic agreements. A decline in transport and communication costs and an increased awareness of, and desire for, world-class consumer goods have been factors underlying the opening of trade and formation of regional trading blocs.¹⁶¹ In order to encourage and administer the reduction of barriers to trade and investment, governments are opening their economies to foreign competition through the removal of import tariffs and non-barriers to trade such as import quotas, export restraints, and other legal prohibitions.¹⁶² Organizations and institutions created to administer various policies and

¹⁵⁹ Mussa, "Factors Driving Global Economic Integration," 3.

¹⁶⁰ *Ibid.*, 3.

¹⁶¹ Alejandro Portes, *Regional Trade Blocs: The Way to the Future* (Washington, DC: Carnegie Endowment for International Peace, 2010), 10.

¹⁶² World Bank, *Globalization and International Trade*, 66.

agreements underpinning such as the World Bank, International Monetary Fund (IMF), and the General Agreements on Tariffs and Trade, which was succeeded in 1995 by the World Trade Organization (WTO), have all played important roles in promoting free trade.¹⁶³ These are the institutions which constitute part of the current global SSA.¹⁶⁴

Globalization is resulting in increased **international trade and financial integration**.

2. Regional Economic, Political Blocs

Parallel with the development of global economic institutions has been the development of regional trading blocs, and more deeply integrated regional unions such as the European Union (EU), the Central European Free Trade Area (CEFTA), Southern Common Market (MERCOSUR), Andean Community (CAN), Central American Common Market (MCCA), Caribbean Community (CARICOM), Association of Southeastern Asian Nations (ASEAN), and others.¹⁶⁵

The process of economic integration has been progressing in stages, with successive rounds of trade and investment liberalization leading to more trade and integration with associated benefits. The perception that subsequent economic growth was causally linked to the economic liberalization has provided the impetus for additional rounds of trade liberalization and other institutional reforms.

The **perception of the benefits of globalization** is leading to **global and regional institution building** and the development of **regional economic and political blocs**.

Although long and uneven, the path of globalization has exhibited the characteristics of circular and cumulative causation explained above. To describe that experience simply at a macro level, the general dynamic can be seen as a virtuous circle of globalization with the perception of the benefits of globalization, leading to waves of

¹⁶³ Ibid.

¹⁶⁴ Kotz and McDonough, "Global Neoliberalism and the Contemporary Social Structure," 18.

¹⁶⁵ Foxley, *Regional Trade Blocs*, 5.

global and regional institution building, which in turn facilitates more global integration. The directional nature of this dynamic is illustrated by the arrows in Figure 4 with all pointing in the same direction.

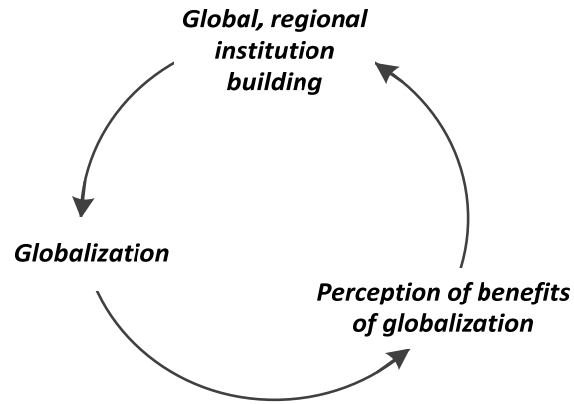


Figure 4.

Figure 4. Globalization dynamic

This is shown again with more detail from the information in the text boxes in Figure 5.

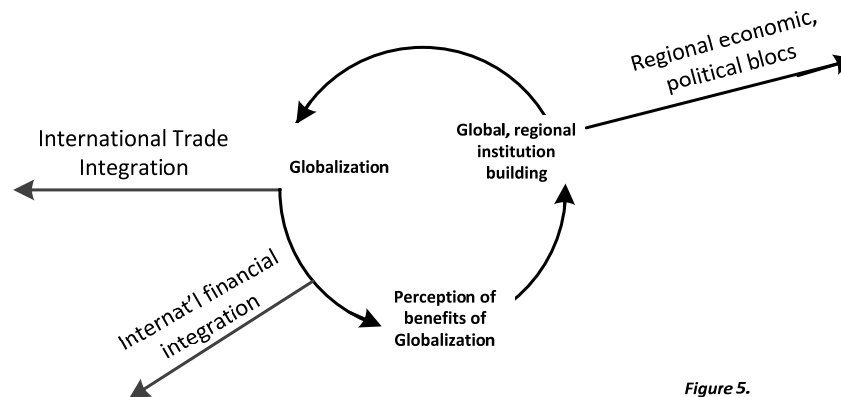


Figure 5.

Figure 5. Globalization dynamic with more detail

Since economic globalization is a main driver of economic growth, and economic growth is main motivator of globalization, we will link globalization to the mega trends by mutually linking globalization with economic growth with a two-directional arrow. Graphically, the globalization cycle intersects with the trends from Figure 2, as shown in Figure 6.

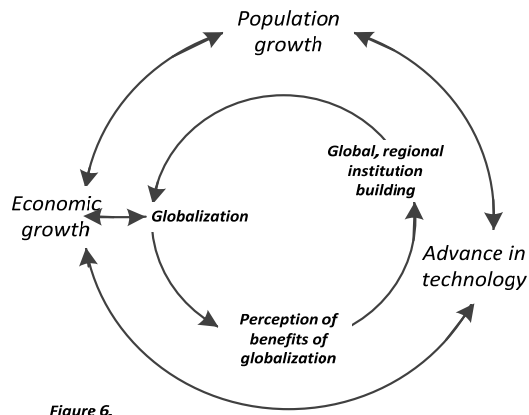


Figure 6. Megatrends and globalization combined

Adding the additional detail of the related topics already covered yields Figure 7.

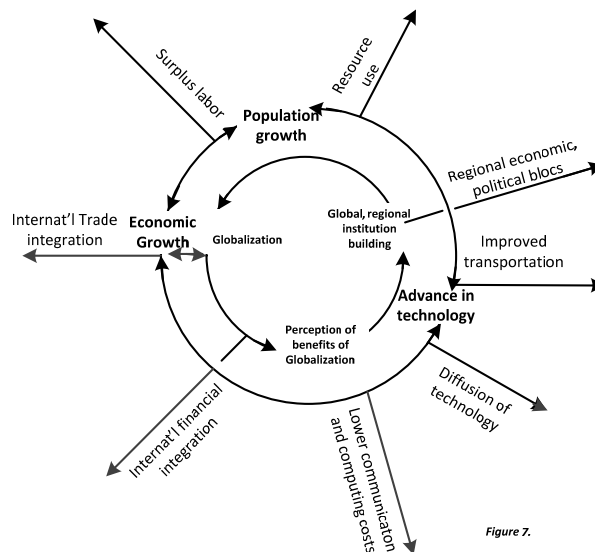


Figure 7. Megatrends and globalization with more detail

Figure 7 illustrates a way to think about the fundamental self-organizing dynamic occurring in the world today. Note that it has many of the characteristics of dissipative systems. It is self-organizing and operates on the principle of circular and cumulative causation or feedback. Over time, through the ongoing, irreversible process of creative destruction, new, more advanced, and qualitatively different economic structures supplant the previous structures. This is reminiscent of the characteristic of dissipative systems to move to new steady states of increasing complexity and dissipation. Another characteristic of dissipative systems is entropy—particularly Prigogine’s approach to entropy in open systems, which holds that according to the entropy law that self-organization results in the exportation of entropy.¹⁶⁶ In the next chapter, we will look at how the self-organizing dynamic occurring in the world results in entropy, or disorder, and self-organized criticality that manifests itself in the form of real world homeland security threats.

¹⁶⁶ Prigogine, Micolis, and Babloyantz, “Thermodynamics of Evolution,” 24.

VI. FINDINGS: THE ORIGINS OF HOMELAND SECURITY THREATS

The second law of thermodynamics concludes that the entropy of universe is increasing with time. Which means with time, the randomness or disorderness is also increasing. Anarchy is the condition of excessive social entropy. Thus, we can conclude that finally universe will reach to the condition of anarchy.

Anup Joshi¹⁶⁷

Earlier, we introduced a model for a social system in which processes of self-organization result in the transfer of entropy, or disorder, to the external environment. The previous chapter modeled the fundamental processes of self-organization occurring in the world. This chapter will explore the idea that homeland security threats can modeled as disorder that is the result of those fundamental processes of self-organization. Before introducing these homeland security threats, let us review the main features of that process of self-organization.

A. HOW THREATS ARE DEFINED AND SELECTED

In the previous chapter, we defined globalization as an ongoing, fundamental process of self-organization occurring in the global homeland security environment of the United States. The following trends were identified earlier as being important consequences of globalization:

- Increased resource use
- The development of regional economic and political blocs
- Improved transportation—improved means, and more developed networks
- The diffusion of technology
- Lower communications and computing costs
- Increase international financial integration

¹⁶⁷ “Quotes about Social Entropy,” accessed January 17, 2015, <http://www.goodreads.com/quotes/tag/social-entropy>.

- Increased international trade integration
- A tendency toward the growth of surplus labor

Now, we will link these trends to homeland security threats as DHS and others see them.

The first-ever *Quadrennial Homeland Security Review* published in February 2010 and the Worldwide Threat Assessment of the U.S. Intelligence Community of March 2013¹⁶⁸ provided a conceptual framework for organizing into “threats and hazards,” which include:

- High-consequence weapons of mass destruction
- Al-Qaeda and global violent extremism
- High-consequence and/or wide scale cyber-attacks, intrusions, disruptions, and exploitations
- Pandemics, major accidents, and natural hazards
- Illicit trafficking and related transnational crime
- Smaller scale terrorism¹⁶⁹

The review identified other “global challenges and trends” related to homeland security, namely:

- Economic and financial instability
- Dependence on fossil fuels and the threat of global climate change
- Nations unwilling to abide by international norms
- Sophisticated and broadly available technology (and)
- Other drivers of illicit, dangerous, or uncontrolled movement of people and goods.¹⁷⁰

If the global environment that gives rise to the homeland security threats really does behave like a dissipative system, at least on the descriptive level, then causal linkages should exist between the self-organizing dynamics of globalization and its accompanying trends, and the major homeland security threats facing the United States. Additionally, since a dissipative system is a complex system, we would expect to see

¹⁶⁸ *Statement for the Record Worldwide Threat Assessment of the U.S. Intelligence Community Senate Select Committee on Intelligence*, 113th Cong (2013) (testimony of James R. Clapper), accessed February 7, 2015, <http://www.intelligence.senate.gov/130312/clapper.pdf>.

¹⁶⁹ DHS, *Quadrennial Homeland Security Review*, viii.

¹⁷⁰ Ibid.

multiple, mutually reinforcing causal linkages between some of the trends and homeland security threats. The claim is that such complex causal linkages do exist. The remainder of this chapter will explore and document these linkages, starting with the threat of pandemic.

B. PANDEMIC

Lower shipping costs and the development of a globalized transportation infrastructure have spurred the development of international trade and economic integration and facilitated human migration.¹⁷¹ Three important health-related consequences of global transport network expansion are *vector invasion events*, *vector-borne pathogen importation*, and *infectious disease pandemics*.¹⁷² According to Tatum, Rogers, and Hay, aircraft and ships are believed to have facilitated the spread of many organisms, including diseases.¹⁷³ As air, sea, and land transport networks continue to expand in reach, speed of travel, and volume of passengers and goods carried, pathogens and their vectors can now move further, faster, and in greater numbers than ever before.¹⁷⁴ The characteristics of modern transport are making a quarantine approach to fighting disease transmission practically irrelevant.¹⁷⁵ The threat of “zoonotic diseases,” which unexpectedly jump from animals to humans, also remains a concern.¹⁷⁶ Recall that the threat of pandemic is a major concern for DHS. New ways of understanding and combatting the spread of diseases are needed.

Ted Lewis understands pandemics in terms of self-organized criticality. Increased population density and the clustering of people into large venues is a kind of “people clustering” that facilitates the spread of disease.¹⁷⁷ The spread of a disease can be

¹⁷¹ Mussa, “Factors Driving Global Economic Integration,” 8.

¹⁷² A. J. Tatum, D. J. Rogers, and S. I. Hay, “Global Transport Networks and Infectious Disease Spread,” 2006, U.S. National Library of Medicine, National Institutes of Health, accessed November 10, 2013, <http://www.ncbi.nlm.nih.gov/pubmed/16647974>, 1.

¹⁷³ *Ibid.*, 7.

¹⁷⁴ *Ibid.*

¹⁷⁵ *Ibid.*, 15.

¹⁷⁶ *Statement for the Record Worldwide Threat Assessment*, 12–13.

¹⁷⁷ Lewis, *Bak’s Sand Pile*, 108–109.

modeled as a power law by plotting frequency of transmission against the distance traveled between the contraction of the disease and the next transmittal.¹⁷⁸ A pandemic will be “attenuated,” or die out on its own if the exponent of the power law is less than or equal to 2.¹⁷⁹ There is a lateral linkage with *transport integration*. To summarize:

Improved transportation leads to lower shipping costs which facilitates **international trade** and **human migration**, but at the same time creates **more vectors for disease transmission**, resulting in an increased **threat of pandemic**.

C. CYBER-ATTACK AND CYBER-CRIME

The rapid growth of the Internet is transforming the way we live, our critical infrastructure, and the global economy, but at times digital technology is progressing faster than our ability to understand and mitigate potential risks.¹⁸⁰ As a consequence, the U.S. finds itself under a growing threat of cyber-attack. Cyberspace is built in a way that makes it “inherently insecure.”¹⁸¹ Foreign state and non-state actors are increasingly using the Internet to achieve their objectives.¹⁸² The rapid growth, open architecture, and frequent lack of strategic systems planning to ensure network security have led to both greater complexity of communications systems and left them with systemic vulnerabilities, which can be and are exploited.¹⁸³ Cyber-attacks have the potential to “massively disable or impair critical international financial, commercial, physical, and other infrastructure. This in turn could cripple the global movement of people and goods worldwide and bringing legitimate and vital social and economic processes to a standstill. Cyber-attacks can involve individuals and groups who conduct intrusions in search of information to use against the United States, and those who spread malicious code in an attempt to disrupt the national information infrastructure.”¹⁸⁴ Self-organized criticality in

¹⁷⁸ Ibid., 142–143.

¹⁷⁹ Ibid., 147.

¹⁸⁰ *Statement for the Record Worldwide Threat Assessment*, 1.

¹⁸¹ DHS, *Quadrennial Homeland Security Review*, 29.

¹⁸² *Statement for the Record Worldwide Threat Assessment*, 1.

¹⁸³ Joel Brenner, *America the Vulnerable* (New York: Penguin Press, 2011), 25–73.

¹⁸⁴ DHS, *Quadrennial Homeland Security Review*, 7.

many infrastructure networks could enhance the effectiveness of cyber-attacks against infrastructure.

Cyber vulnerabilities threaten security in other ways. The Internet is being used increasingly by foreign powers to gather sensitive information and trade secrets, allowing potential adversaries to close their technological gaps with the U.S. and gain commercial advantage¹⁸⁵ as well as engage in web-based fraud¹⁸⁶ and financial crimes.¹⁸⁷ Domestic “hacktivists” promoting a political or social objective could also conduct cyber-attacks on government or private company networks.¹⁸⁸ A tie-in to previous sections of the paper is that cyber espionage can also facilitate the transfer of technology. There is a lateral linkage to *ability to radicalize, coordinate online*. To summarize:

Advance in IT leads to lower **communication and computing costs**, but at the same time, creates **Greater IT systemic complexity and vulnerabilities**, which can be exploited by criminals or hostile foreign powers which increases the potential for **cyber crimes, cyber espionage, and cyber attack**

D. THREATS POSED BY INTERNATIONAL ORGANIZED CRIME

Global governance has failed to keep pace with economic globalization. A consequence of this is that changes brought about by globalization have also facilitated the growth of international organized crime.¹⁸⁹ According to the UN, “organized crime has diversified, gone global and reached macro-economic proportions.”¹⁹⁰ Some consequences of the activities of organized crime include:

- Cyber threats posed by organized crime, as covered above.

¹⁸⁵ *Statement for the Record Worldwide Threat Assessment*, 2.

¹⁸⁶ United Nations Office on Drugs and Crime [UNDOC], *The Globalization of Crime: A Transnational Organized Crime Threat Assessment*, 2010, accessed November 13, 2013, http://www.unodc.org/documents/data-and-analysis/tocta/TOCTA_Report_2010_low_res.pdf, ii.

¹⁸⁷ Brenner, *America the Vulnerable*, 25–45.

¹⁸⁸ *Statement for the Record Worldwide Threat Assessment*, 3.

¹⁸⁹ UNDOC, *The Globalization of Crime*, ii.

¹⁹⁰ *Ibid.*

- Organized criminals collude with insurgents in Central Africa, the Sahel, and Southeast Asia, increasing the risks of terrorism. “Facilitation networks” of “semi-legitimate” business people such as travel experts, attorneys and other kinds of professionals may also provide support services for organized crime, or terrorist groups.¹⁹¹
- The diffusion of dangerous technologies and materials, which makes non-proliferation efforts more difficult.¹⁹²
- Crime is fuelling corruption, infiltrating business and politics.¹⁹³ While corruption can occur anywhere, Mexican drug cartels (hereafter “cartels”) pose a significant homeland security threat for the U.S. The cartels operate extensively in the U.S. and U.S. consumers are their biggest customers. In Mexico, the cartels are challenging the government directly by attacking the legitimate army and police forces.¹⁹⁴ The cartels have been described as “criminal insurgencies” which use “fourth-generation warfare” tactics to weaken and supplant the legitimate government to promote their own interests. They use tactical military operations against government forces,¹⁹⁵ and “employ terrorist tactics and weapons to intimidate their adversaries and the public such as decapitations, acid baths, skinning people alive, torture, and the use of improvised explosive devices.”¹⁹⁶ The cartels’ financial expertise is comparable with that of an international terrorist organization, as they have successfully laundered hundreds of billions of dollars through major U.S. banks such as Wells Fargo.¹⁹⁷

From a networks perspective, the rise of the network society has resulted in an erosion of sovereignty and a shift of power from the state to networks, which essentially

¹⁹¹ *Statement for the Record Worldwide Threat Assessment*, 5.

¹⁹² DHS, *Quadrennial Homeland Security Review*, 6.

¹⁹³ UNDOC, *The Globalization of Crime*, ii.

¹⁹⁴ Bob Killebrew and Jennifer Bernal, *Crime Wars: Gangs, Cartels and U.S. National Security* (Washington, DC: Center for a New American Security, 2010), 15.

¹⁹⁵ John Zambri, “A Case for a Joint Police-Military Special Operations Capable Task Force in Response to Mexican Drug Cartel Spill-Over Violence,” *Small Wars Journal* (2013), accessed February 7, 2014, <http://smallwarsjournal.com/jrnl/art/a-case-for-a-joint-police-military-special-operations-capable-task-force-in-response-to-mex>.

¹⁹⁶ Carrie F. Cordero, *Breaking the Mexican Cartels: A Key Homeland Security Challenge for the Next Four Years* (paper 1202), Georgetown University Law Center, 2013, <http://scholarship.law.georgetown.edu/facpub/1202>, 282.

¹⁹⁷ Ed Vulliamy, “How a Big U.S. Bank Laundered Billions for Mexico’s Murderous Drug Gangs,” *The Guardian*, April 2, 2011, accessed January 31, 2014, <http://www.theguardian.com/world/2011/apr/03/us-bank-mexico-drug-gangs>.

by-pass the state. Organized crime is one type of these networks.¹⁹⁸ There is a lateral linkage with *cyber crime*.

International Trade and Investment leads to Economic and Financial Interdependence which, in a situation where governance is not keeping up with integration, leads to **greater opportunities for economic or financial crime**, leading to **threats posed by international organized crime**.

E. ECONOMIC INSTABILITY

International financial integration is generally seen as increasing economic efficiency and growth; however, international financial integration may also increase countries vulnerability to “financial contagion.” Financial contagion is a situation that occurs through international banking when banks of one country respond to deteriorations in their own balance sheets by reducing cross-border loans to clients in countries that are not directly exposed to the initial financial shock¹⁹⁹ and in so doing may transmit a financial crisis to another country. Financial contagion may increase the risk of economic instability.

As network organization has increased in the world, globalized capital markets have become the dominant sphere of capital where value of any asset increases, decreases, or is realized.²⁰⁰ Castells describes capital in the Network Age as “a human-made automaton, which, through mediations, imposes its structural determination to relationships of production.”²⁰¹ This means that financial crashes can have far reaching economic consequences.

Stock market crashes strongly resemble avalanches, so self-organized criticality has been used to explain them.²⁰² Lewis uses self-organized criticality to explain the

¹⁹⁸ Castells, “Materials for an Exploratory Theory of the Network Society,” 19.

¹⁹⁹ Franklin Allen and Douglas Gale, “Financial Contagion,” *Journal of Political Economy* 108, no. 1 (2000): 4.

²⁰⁰ Castells, “Materials for an Exploratory Theory of the Network Society,” 17.

²⁰¹ Ibid.

²⁰² Turcotte, “Self-organized Criticality,” 1418.

financial crash of 2007²⁰³ by citing work done by Amaral and Martin, which modeled financial interrelatedness and linkages among major banks, insurance companies, and institutional investors. Furthermore, Amaral and Martin used a “food network” model to represent the interdependency among financial institutions due to reciprocal investments. The “degree of connectivity” among the financial institutions represented percolation of ties among them which intensified to a point of self-organized criticality.²⁰⁴ At this point, the collapse of the savings and loan industry set off a chain reaction that affected global finance. The global nature and increased interrelatedness of trade and financial markets, and the tendency for the profit motive to create a strong incentive for the optimization of financial and economic systems, leads to the removal of excess capacity from the system. The result is percolation. Without mitigating policy measures, it seems that in the future economic or financial contagion will be increasingly likely.²⁰⁵

Also, in globalized markets, countries can be vulnerable to contagions or “shocks” caused by sudden changes in global prices and global demand for their products (although these shocks can also be of a positive nature). These shocks can be *terms-of-trade shocks*, which result from a falling price of a country’s exports, or rising prices of imports (or vice versa), or a *demand shock*, which is due to changes in volume of exports demanded by the rest of the world, or imports demanded from the rest of the world.²⁰⁶

Economic and financial interdependence create conditions where there is a **greater chance of economic or financial contagion**, leading potentially to an **increased threat of economic instability**.

F. SUPPLY CHAIN ATTACK

A specific threat that is emerging from economic globalization is sabotage done by corrupting a product at the place of manufacture, or more often, somewhere along the

²⁰³ Lewis, *Bak’s Sand Pile*, 80–86.

²⁰⁴ Ibid., 89–90.

²⁰⁵ Ibid., 90.

²⁰⁶ Alex Izurieta and Rob Vos, *Trade Shock Analysis* (New York: World Economic Vulnerable Monitor, 2009), 2.

supply line between the manufacturers loading dock and the point of delivery. Joel Brenner calls this kind of attack a “supply chain attack.”²⁰⁷ The growing international interdependence of the supply chains for a wide variety of products of strategic significance increases our vulnerabilities and raises the possibilities of this kind of attack. For example the United States has off-shored most of our computer chip manufacturing and much of our software writing to Asia.²⁰⁸ Foreign adversaries could plant defective or malicious computer code or chips or other kinds of defective objects into supply chains destined for products of major significance. It should be noted that the interdependence of the international supply chain works both ways, and the U.S. can also engage in supply chain attacks. Lateral linkage to *offshoring of production*.

Economic interdependence leads to supply chain interdependence and vulnerabilities which lead to vulnerability to and threat of supply chain attack.

G. WMD, NUCLEAR, CHEMICAL, BIOLOGICAL ATTACK

Technology transfer, by legitimate and illegitimate means, has been covered previously. One consequence of technology transfer that poses a direct homeland security threat is the transfer of dual use or technology related to weapons of mass destruction (WMD), which complicates WMD nonproliferation and counter proliferation efforts, especially related to nuclear and biological technology.²⁰⁹ This increases the possibility that these technologies could fall into the wrong hands, increasing the threat of WMD, nuclear, chemical, or biological attack. (Diffusion of technology has lateral linkages with *cyber espionage* and *immigration*).

International trade, foreign direct investment, human migration, espionage (especially cyber) and other factors related to personal communications contribute to the diffusion of dual use and military technology which increases the threat of WMD, nuclear, chemical, biological attack.

²⁰⁷ Brenner, *America the Vulnerable*, 151.

²⁰⁸ Ibid., 236.

²⁰⁹ DHS, *Quadrennial Homeland Security Review*, 9.

H. CIVIL CONFLICT

Like many threats to homeland security dealt with in this paper, the origins of civil conflict are complex. One major factor that can contribute to the likelihood of civil conflict is growing income inequality.

1. Growing Income Inequality

In general, during the recent period of economic globalization the world economy has grown at a rapid rate; however, income inequality has also grown within and among countries. The income gap between the rich and poor in within Organization for Economic Cooperation and Development (OECD) member countries has widened over the past 30 years.²¹⁰ Many developing countries continue to have a wide gap between rich and poor. There is currently a confluence of factors that are working to create downward pressure on the wages of many Americans and Europeans.

Technological changes are having a major impact in income distribution. *Skill-biased technological change* is the tendency for technological advances to favor skilled workers by disproportionately increasing their productivity and is contributing to growing income inequality.²¹¹ Skill-biased technological change can help account for the surge in income at the top of the distribution. In developed countries, each cycle of innovation destroys more mid-level jobs than it creates because the relatively high labor costs of these jobs creates an incentive to replace them with *automation*.²¹² *Offshoring* of production could also help explain the stagnation of wages for middle income earners.²¹³ Manders and Brenner observe that globalization is leading companies to adopt a “strategy of worldwide outsourcing, leading to a search for ever cheaper labor, a flexibilisation of

²¹⁰ Organization for Economic Co-operation and Development [OECD], *Divided We Stand: Why Inequality Keeps Rising*, 2011, accessed November 10, 2013, <http://www.oecd.org/els/soc/49170768.pdf>, 1.

²¹¹ Tali Regev and Daniel Wilson, “Changes in Income Inequality Across the U.S.,” *FRBSF Economic Letter*, no. 2007–28 (September 2007): 1–2, <http://www.frbsf.org/economic-research/publications/economic-letter/2007/september/us-income-inequality/>.

²¹² Rahul Gupta Iwasaki, “Technology and Unemployment, Part II: The Rising Tide,” *Stanford Daily*, November 20 2013, accessed January 29, 2014, <http://www.stanforddaily.com/2013/11/20/technology-and-unemployment-the-rising-tide/>, 2.

²¹³ Regev and Wilson, “Changes in Income Inequality Across the U.S.” 1–2.

labour and the adoption of new international production technology and production organization concepts.”²¹⁴ They conclude that recent technological developments and production strategies cause a more “lopsided” distribution of income between consumers and “controllers of capital,”²¹⁵ leading to more polarization of society. *Immigration* of low skilled workers can reduce wages at the bottom end of the wage scale.²¹⁶

The emergence of network society also plays a role. Networks are able to link together valued assets located anywhere in the world. At the same time, the global network economy can also discard resources (people, firms, territories, other resources) that have no value or become devalued, resulting “in a variable geometry of creative destruction and destructive creation of value.”²¹⁷ The new, globalized network economy is winnowing labor into two categories: self-programmable labor, which can retrain itself as work demands change and successfully adapt to new conditions, and generic labor, which is “exchangeable and disposable” and competes with machines and other generic labor around the globe. This dichotomy of labor is leading to increasing inequality, social polarization, and social exclusion.²¹⁸

Income distribution follows a power law.²¹⁹ From the standpoint of Kafri’s mathematical modeling of distributions and the entropy principle mentioned previously, the number of particles (people) to be modeled in the integrated market will be greater in a market globalized by increasingly free trade, while the number of boxes remains constant. This should reinforce the ‘power law’ characteristics of the wealth distribution curve, further skewing the distribution of income. (Vertical links to *surplus labor* and *downward wage pressure*.)

²¹⁴ A. C. Manders and Y. S. Brenner, “Globalization, New Production Concepts and Income Distribution,” *International Journal of Social Economics* 26, no. 4 (1999): 564.

²¹⁵ Ibid., 567.

²¹⁶ Regev and Wilson, “Changes in Income Inequality Across the U.S.,” 1.

²¹⁷ Castells, “Materials for an Exploratory Theory of the Network Society,” 10.

²¹⁸ Castells “Materials for an Exploratory Theory of the Network Society,” 12.

²¹⁹ Alok Jha, “The Mathematical Law that Shows Why Wealth Flows to the 1%,” *The Guardian*, November 11, 2011, accessed September 15, 2014, <http://www.theguardian.com/commentisfree/2011/nov/11/occupy-movement-wealth-power-law-distribution>.

Immigration, skill biased technical change, automation, offshoring of production, and the loss of jobs to foreign trade competition all contribute to growing income inequality.

The income gap between countries has also grown. The benefits of globalization have accrued mostly to countries in East Asia and some in Latin America, while much of the rest of the world has lagged behind.²²⁰ Large income differentials between countries are likely to play a very important role in determining migration flows.²²¹ As noted above, declining transportation costs also lowers barriers to human migration.

Growing income inequality can motivate human migration.

In a similar vein, Kinnvall observes, “a number of factors related to globalization seem to increase the gaps between those who have reaped the benefits of the global market and those who have been left behind.”²²² Moghaddam echoes this by pointing out that globalization is characterized by “enormous contradictions, inequalities, and conflicts.”²²³ Although vast wealth is being created, globalization has increased inequalities around the world.²²⁴ In many parts of the world, the poor are being left further behind.

Expectations can play a significant role in people’s perceptions of justice. Even when their material condition may be improving in an absolute sense, people may feel a sense of *relative deprivation* when compared to others around them.²²⁵ One theoretical approach explains “revolutions and collective violence” as a response to a gap between

²²⁰ World Bank, *Globalization and International Trade*, 66.

²²¹ Francesc Ortega and Giovanni Peri, “The Effect of Income and Immigration Policies on International Migration,” National Bureau of Economic Research, 2012, accessed November 15, 2013, <http://www.nber.org/papers/w18322>, 3.

²²² Catarina Kinnvall, “Globalization and Religious Nationalism: Self, Identity, and the Search for Ontological Security,” *Political Psychology* 25, no. 5 (2001): 742.

²²³ Fathali M. Moghaddam, *How Globalization Spurs Terrorism* (Westport, CT: Praeger Security International, 2008), 74.

²²⁴ Ibid.

²²⁵ Ibid., 74.

expectations and outcomes that result in “hardship in a collectivity”²²⁶ (i.e., as an increase in the sense relative deprivation of a group, or *fraternal deprivation*),²²⁷ which can come along with other identity-based issues. More on this later.

The Gini coefficient is a measure of income inequality.²²⁸ As mentioned earlier, income inequality has been growing in the U.S. and European countries for the last 30 years and remains high in many developing countries.²²⁹ Yitzhaki has shown that the Gini coefficient of inequality provides a direct theoretical measure of relative deprivation,²³⁰ and it has been increasing.

The literature regarding income inequality and civil conflict is diverse and complex because there are more factors at play in social conflict than just income inequality, such as heterogeneity of language, ethnic origins and religion, geography, national history, and levels of education.²³¹ The chances of civil conflict are enhanced if wealth inequality is between different ethnic or regional groups, and when there is an economic recession, while increases in wealth and economic growth tend to reduce the chances.²³² While it may not be possible to make accurate assessments of specific situations related to social conflict based solely on income distribution, it is possible to make some broad inferences about income inequality and the threat of civil conflict. Income inequality is regarded as a crucial factor leading to social conflict and political instability.²³³ In other words, with all other things equal, growing income inequality within a society may well increase the *chances* of civil unrest or civil war. (Lateral

²²⁶ Walter Korpi, “Conflict, Power, and Relative Deprivation,” *The American Political Science Review* 68, no. 4 (1974): 1569.

²²⁷ Moghaddam, *How Globalization Spurs Terrorism*, 49.

²²⁸ Steven J. Markovich, “The Income Inequality Debate,” Council on Foreign Relations, September 17, 2012, accessed December 30, 2013, <http://www.cfr.org/united-states/income-inequality-debate/p29052>, 1.

²²⁹ OECD, “Divided We Stand: Why Inequality Keeps Rising,” 1.

²³⁰ Shlomo Yitzhaki, “Relative Deprivation and the Gini Coefficient,” *The Quarterly Journal of Economics* 93, no. 2 (1979): 324.

²³¹ Eric Thornbecke and Charumilind Chutatong, “Economic Inequality and Its Socioeconomic Impact,” *World Development* 30, no. 9 (2002): 1486.

²³² Macartan Humphries, *Economics and Violent Conflict*, 2002, accessed November 18, 2013, http://www.unicef.org/socialpolicy/files/Economics_and_Violent_conflict.pdf, 20–21.

²³³ Thornbecke and Chutatong, “Economic Inequality and Its Socioeconomic Impact,” 1486–1487.

linkage to the *threat of identity-based conflict, terrorism*—lateral linkages to the causes of *growing income inequality*).

Growing income inequality can (with other factors) lead to **increased social tensions** and increase the **threat of civil conflict**.

I. ADVERSE EFFECTS OF CLIMATE CHANGE

As noted earlier, the growth in global population was defined as a macro-trend that has been continuing for centuries and is expected to continue well into this century. Since 1960, global population more than doubled from three to 7.2 billion people, and it is projected to reach nine billion later in this century.²³⁴ During the same period, changes in the global environment began to accelerate and trends toward increased pollution and resource depletion intensified.²³⁵ If demand for resources is expanding as the same resources are being depleted, resource scarcity can be the result.

Fossil fuels have major strategic and environmental, and therefore homeland security, significance. The first *Homeland Security Quadrennial Homeland Security Review* mentions that “dependence on fossil fuels and the threat of global climate change”²³⁶ are major homeland security concerns. The rising global population is causing an increase in industrial production and consumption of energy derived from fossil fuels, leading to an increase in the emissions of carbon dioxide, which is believed to be causing a buildup of greenhouse gases (mostly CO₂), resulting in climate change.²³⁷ Climate change is expected to increase the severity and frequency of weather-related hazards and rising sea level, which could, in turn, result in social and political destabilization, international conflict, or mass migrations,²³⁸ and these clearly represent a wide array of homeland security challenges.

²³⁴ UNFPA, “Linking Population, Poverty, and Development,” 1–2.

²³⁵ Hunter, *Population and Environment*, 3.

²³⁶ DHS, *Quadrennial Homeland Security Review*, iii.

²³⁷ Hunter, *Population and Environment*, 3.

²³⁸ DHS, *Quadrennial Homeland Security Review*, 7.

DHS outlined four strategic objectives in response to the effects of climate change in the 2010 *Quadrennial Review*:

1. Manage climate change risks for cross-cutting or other key homeland security issues.
2. Protect and ensure the resilience of critical infrastructure and key resources (CIKR) to potential impacts of climate change.
3. Ensure the Nation's resilience to more frequent or extreme weather events and natural disasters.
4. Contribute to safety, stability, security and environmental protection in the Arctic.²³⁹

There is a lateral linkage from perception of manmade climate change to radical environmentalism.

Population growth leads to increased **resource use**. **Resource use** also leads to **pollution**, and, in the case of the utilization of fossil fuels, **greenhouse gas buildup**, which leads to **climate change**, and the **adverse effects of climate change**.

J. ENVIRONMENTAL DEGRADATION AS ENTROPY TRANSFER TO THE ENVIRONMENT

Environmental degradation can be seen as a direct physical entropy transfer to the environment. Thermodynamically, all work increases physical entropy. This means that economic processes that convert raw materials into products increase physical entropy,²⁴⁰ mainly in the form of waste. As complex environmental systems become disordered, they may not be able sustain human life on the same level as before. Nicolas Georgescu-Roegen, a contemporary and protégé of Joseph Schumpeter,²⁴¹ noted that the factors of production can be divided into two categories: the fund elements (capital), “which represent the *agents* of the process, and the flow elements, which *are used or acted upon*

²³⁹ Department of Homeland Security, *Climate Change Adaptation Roadmap*, 2012, accessed November 10, 2013, http://www.dhs.gov/sites/default/files/publications/Appendix%20A%20DHS%20FY2012%20Climate%20Change%20Adaptation%20Plan_0.pdf, 7.

²⁴⁰ Swanson, Bailey, and Miller, “Money: A Living Systems Theory Perspective,” 45–65.

²⁴¹ John Gowdy and Susan Mesner, “The Evolution of Georgescu-Roegen’s Bioeconomics,” *Review of Social Economy* 56, no. 2, 1998: 139.

by the agents.”²⁴² However, whether a factor is a fund or flow element can depend on the time frame used to evaluate the process.²⁴³ From a long-term perspective, economic processes can result in the degradation or depletion of “fund elements” such as water and soil.²⁴⁴

Georgescu-Roegen believed that the combination of the continuing rising world population, uneven distributions of population and resources and resource scarcities make long-term, continued economic growth biologically unsustainable, as entropy processes make more energy and material resources unusable.²⁴⁵ In order to properly account for long-term resource degradation, Georgescu-Roegen believed it is necessary to stop discounting the future in economic calculations, and incorporate the costs of environmental degradation into the cost of products.²⁴⁶

Large-scale environmental degradation can have a major impact on homeland security, as it can reduce economic output, incite the migration of people that can result in conflict, or lead to conflict over the remaining usable resources. Threats to homeland security from climate change have already been mentioned. As the global population growth places more strains on a shrinking amount of usable resources, threats to homeland security that arise as a byproduct of environmental degradation can be expected to increase and intensify over time. Eco-terrorism is relatively less significant than other potential long-term homeland security threats associated with environmental degradation, but it will be covered here due to its place in the homeland security literature.

K. ECO-TERRORISM

As mentioned earlier, a rapidly increasing global population has resulted in pollution, environmental degradation, and the threat of global warming. These facts,

²⁴² Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process* (Cambridge: Harvard University Press, 1971), 230.

²⁴³ *Ibid.*, 230–231.

²⁴⁴ Gowdy and Mesner, “The Evolution of Georgescu-Roegen’s Bioeconomics,” 146.

²⁴⁵ Georgescu-Roegen, *The Entropy Law and the Economic Process*.

²⁴⁶ *Ibid.*, 375.

coupled with complex social processes, have led to the development of the environmentalist movement. In some countries, this movement has become radicalized over time.

The environmentalist movement traces its philosophical roots to the nineteenth century Transcendentalists. Mainstream environmental groups, such as the Humane Society, Sierra Club, The Wilderness Society, and The Nature Conservancy, tend to limit their activities to lawful protests, demonstrations, mild forms of civil disobedience, and conventional political lobbying. Some environmentalists were dissatisfied with the results obtained by these means split off to form more aggressive organizations. Organizations such as Friends of the Earth, Greenpeace, Sea Shepherd, and People for the Ethical Treatment of Animals, (PETA) have taken more of a “by whatever means necessary approach”²⁴⁷ to their activities. Later, the perception of increased threat to the environment led to the formation of the “monkey wrenching” group, Earth First!, which engaged in acts of environmental sabotage, such as tree spiking.²⁴⁸ Later, militant groups that engage in actual eco-terrorism emerged, with the Earth Liberation Front (ELF) appearing in England in 1992 and then quickly spreading to the U.S.²⁴⁹ DHS now considers eco-terrorism to be a significant homeland security threat. (Lateral linkages to *pollution and perceptions of man-made climate change.*)

Environmental degradation has led to environmentalism and then **radical environmentalism**, which in turn has led to the **threat of eco-terrorism**.

²⁴⁷ Nick Deshpande and Howard Ernst, *Countering Eco-Terrorism in the United States: The Case of Operation Backfire* (College Park, MD: Science and Technology Directorate, U.S. Department of Homeland Security, 2012), 8.

²⁴⁸ Horacio R. Trujillo, “The Radical Environmentalist Movement,” in *Aptitued for Destruction, Vol. 2 Case Studies of Organizational Learning in Five Terrorist Groups*, ed. Brian A. Jackson et al. (141–175) (Santa Monica: RAND, 2005), 151.

²⁴⁹ *Ibid.*, 151–152.

L. THREAT OF IDENTITY-BASED CONFLICT, TERRORISM

Globalization is bringing increasing numbers of cultures into contact with each other. Some of the resulting interactions have significant implications for homeland security. These interactions begin with migration.

1. Human Migration

Human migration is a key trend that has many causes that have been mentioned in this paper. These include:

Wars, civil conflict, increased social tensions, growing income inequality, crowding, resource depletion, and lower shipping costs (transportation cost), and other factors can contribute to **human migration**.

Human migration is currently at an all-time high. Between 2000 and 2010, the “global migrant stock” grew at an average of 4.6 million per year, and in 2013, there were 232 million people living outside their country of birth.²⁵⁰ Human migration has a variety of causes, including response to wars, political and social turmoil, and economic reasons such as income differentials.²⁵¹ Human migration has also been a fundamental factor affecting nature of economic integration.²⁵² As a long-term trend, the process of human migration has brought many diverse human groups together. For some groups, the results of these encounters are catastrophic.

2. Catastrophic Evolution

The process of globalization impacts different groups of people differently. Moghaddam meta-theoretically borrows ideas from evolution to define a concept of “catastrophic evolution,” to describe “swift, sharp, and often fatal” declines of some life

²⁵⁰ United Nations Department of Economic and Social Affairs, Population Division, *World Migration in Figures* (New York: Organization for Economic Co-operation and Development, United Nations Department of Economic and Social Affairs, 2013), 1.

²⁵¹ Mussa, “Factors Driving Global Economic Integration,” 10.

²⁵² *Ibid.*, 5–8.

forms when they come into “sudden contact” with each other.²⁵³ Moghaddam describes “preadaptiveness” as a measure of the likelihood for successful evolution in a given environment in contact with given competitors and “postcontact adaptation speed” as how quickly a life form can adapt to new environmental conditions and the presence of new competitors.²⁵⁴ A life form with a high preadaptiveness and high post contact adaptation speed will face less of a threat from sudden contact than one with low preadaptiveness and low postcontact adaptation speed, which may suffer a rapid decline or even extinction upon rapid contact.²⁵⁵

From a biological perspective, sudden contact between species brought about by human transport systems has led to rapid extinctions of species and a reduction in biodiversity.²⁵⁶ These catastrophic extinction events are seen by some as manifestations of self-organized criticality in eco-systems.²⁵⁷ Sudden contact can also have catastrophic effects on human cultural groups. Moghaddam cites the declines of indigenous people in the Americas and Africa and the extinction of native Tasmanians as examples of catastrophic evolution.²⁵⁸ Globalization is contributing to catastrophic evolution, which is causing a marked reduction of language and religious diversity in the world.²⁵⁹ Some cultures are essentially going extinct. While the appropriateness of Moghaddam’s application of biological theories to interactions and conflicts among people that are mainly cultural may be questioned, he does make an important point: globalization is bringing increasing numbers of groups into contact with each other, and for many of these groups, the results truly are catastrophic. Many groups feel their existence is being threatened by changes going on in the world today, and many are correct in this assessment. Moghaddam asserts that radicalization and terrorism can be understood in the

²⁵³ Moghaddam, *How Globalization Spurs Terrorism*, 96–97.

²⁵⁴ Fathali Moghaddam, “Catastrophic Evolution and Diversity Management Policy,” *Culture & Psychology* 12, no. 4 (2006): 421.

²⁵⁵ Moghaddam, *How Globalization Spurs Terrorism*, 97–98.

²⁵⁶ Moghaddam, “Catastrophic Evolution and Diversity Management Policy,” 422.

²⁵⁷ Turcotte, “Self-organized Criticality,” 1416–1417.

²⁵⁸ Moghaddam, “Catastrophic Evolution and Diversity Management Policy,” 423.

²⁵⁹ *Ibid.*, 426.

context of defense mechanisms adopted by human groups that feel threatened with extinction.²⁶⁰

3. Catastrophic Evolution as Entropy Transfers among Cultures

Catastrophic evolution deals with interactions among ethnic groups and cultures. The cultural aspects of interactions are psychological in nature and difficult to model; however, there does seem to be a pattern occurring that is descriptively similar to the dynamic of entropy transfer put forth in this paper but with entropy being transferred among cultures.

Cultures are sustained in the minds of people, and so “minds” can be seen as the input needed to sustain cultures. There are a limited number of people in the world at any given time. When people from different cultures come into contact with each other, individuals from the contacting cultures will find themselves in simultaneous contact with these different cultures. If one culture, for whatever reason, is able in aggregate to gain greater influence over the minds of a greater number of people than another, then one culture will expand and another will decline. The expanding culture could be said to be undergoing self-organization while the declining culture would be suffering entropy. Entropy transfers among cultures could occur through a continuum of mechanisms that parallel the different modes of entropy transfer covered earlier. Additionally, entropy could be transferred through completely voluntary and passive means as people adopt one culture and abandon another for whatever reason; people could be forcibly compelled to abandon their previous culture and adopt another; or the members of one culture could simply destroy the members of another and then occupy the space with members of their own culture. All of these scenarios have occurred within the context of catastrophic evolution.

This process of entropy transfer among cultures has similarities to the economic entropy transfer among firms under creative destruction. Cultures, like firms, are self-organizing in dynamic and irreversible ways. They are constantly interacting with one another and their environment. As with the interaction among firms, the interactions

²⁶⁰ Moghaddam, *How Globalization Spurs Terrorism*, 99–100.

among cultures need not necessarily result in an entropy transfer, and the net results of such interactions may be viewed subjectively. Also like firms, cultures are not insular and monolithic. They interact with one another and their environment, and change as a result. Just as the assets of one firm can be acquired by another via a bankruptcy process, the attributes of one culture may be subsumed into another, even as one culture is going extinct. In other words, while different idea mechanisms for entropy transfers are explained categorically above, the actual dynamics are less clear in practice. In general, however, over time, some cultures definitely are beating out others and destroying or subsuming their parts, even though some aspects of the dying culture may be preserved within the dominant culture. In other words, some cultures grow and expand at the expense of others, which degrade and even disappear, and entropy transfer can explain this dynamic. Catastrophic evolution is similar to creative destruction, and both are consistent with the dynamics of a dissipative system exporting its entropy to its surroundings as it self-organizes.

Another way of looking at catastrophic evolution from the point of view of entropy transfers is that culture is an aspect of living social systems. As these systems self-organize or undergo entropy processes, the “culture” within them does so as well. While subtle competition with other cultures on a psychological level or violent conflict can facilitate entropy transfer, disease is also a major vehicle. As mentioned earlier, improved means of transportation and more developed transportation networks facilitate the spread of disease. If sudden contact spreads a lethal disease a population without resistance, the affects can be catastrophic to the population, which can also reduce the number of adherents to a culture. The net effect is entropy transfer to that living social system, however unintended. Regardless of mechanism, changes in the world are making some members of some cultures feel under threat, and some are responding violently.

4. Ontological Insecurity

Globalization and the accompanying specter of catastrophic evolution is causing a reaction from some cultures that feel under threat. According to Moghaddam, “the push toward globalization, associated with integration into larger and larger units, might make

sense economically, but it runs against the human tendency to want to identify with local groups, places, and events.”²⁶¹ At the same time, even the “larger identity units available in third world societies “are also “under pressure to change to fit modern, global standards.”²⁶² The evolution of terrorism should be viewed within the context of the resulting “tensions and paradoxes.”²⁶³

Moghaddam points out, “What is common to human experience around the world is a sense of loss of control, albeit to different degrees, and a basic need for a minimal level of control;”²⁶⁴ however, “globalization involves changes that impact the sense of control humans experience.”²⁶⁵ Numerous minorities “are questioning the impact of globalization. The sheer speed, size and sweep of globalization forces are leading to a sense of powerlessness.”²⁶⁶

According to Kinnvall, globalization is causing for many an “increasing rootlessness and loss of stability as people experience the effects of capitalist development, media overflow, structural adjustment policies , privatization, urbanization, unemployment, forced migration, and other similar transformative forces.”²⁶⁷ The resulting stress causes individuals to feel “vulnerable” and experience an “existential anxiety” or “ontological insecurity,”²⁶⁸ which may cause them to seek to reaffirm their self-identity. Kinnvall asserts, “the combination of religion and nationalism is a particularly powerful response (‘identity-signifier’) in times of rapid change and uncertain futures, and is therefore more likely than other identity constructions to arise during crises of ontological insecurity.”²⁶⁹

²⁶¹ Moghaddam, “Catastrophic Evolution and Diversity Management Policy,” 30.

²⁶² Ibid., 30.

²⁶³ Ibid.

²⁶⁴ Moghaddam, *How Globalization Spurs Terrorism*, 120.

²⁶⁵ Ibid.

²⁶⁶ Fathali Moghaddam, *From the Terrorists’ Point of View: What They Experience and Why They Come to Destroy* (Westport, CT: Praeger Security International, 2006), 29.

²⁶⁷ Kinnvall, “Globalization and Religious Nationalism,” 743.

²⁶⁸ Ibid., 742.

²⁶⁹ Kinnvall, “Globalization and Religious Nationalism,” 741.

Consistent with Kinnvall's analysis, many of the major separatist and terrorist groups operating in the world today are founded on a religious nationalistic identity. The rise of network society is contributing to this trend, as the weakening of power and legitimacy of the state is causing people to "build their own systems of representations around their identities, further delegitimizing the state."²⁷⁰ Lateral linkage to *local orientation* and *ability to radicalize, coordinate online*.

Globalization, global and regional institution building and human migration contribute to ontological insecurity.

5. Technology and Radicalization

In describing the impact of the network society in the cultural realm, Castells observed how the Internet and technologies are making media able to send "targeted messages to specific segments of audiences, responding to specific moods of audiences."²⁷¹ An increased compatibility and instructiveness of media allow for most cultural exchange to occur by means of this technology, resulting in a culture of "real virtuality" that molds people's views of their reality.²⁷² Under such conditions, individuals can immerse themselves in specific messages and perspectives of their choosing. In certain situations, this can facilitate a radicalization process.

As with many other threats, the growth of the Internet has radically changed the structure and dynamic of the evolving threat of Islamic terrorism.²⁷³ (Of course, other kinds of terrorist groups are exploiting the functionality of the Internet, as well.) Castells claims that networks drive out other forms of organization.²⁷⁴ It appears that over time certain aspects of the activities of radical jihadists have moved from face-to-face

²⁷⁰ Castells, "Materials for an Exploratory Theory of the Network Society," 14.

²⁷¹ Ibid., 12.

²⁷² Ibid., 21.

²⁷³ Marc Sageman, *Leaderless Jihad: Terror Networks in the Twenty-first Century* (Philadelphia: University of Pennsylvania Press, 2008), 109.

²⁷⁴ Castells, "Materials for an Exploratory Theory of the Network Society," 16.

communication to cyber space. The Internet allows for passive indoctrination, or interactive communication and the development of relationships online.²⁷⁵ Thompson explains how:

Al Qaida and its affiliates understand the Western world's reliance on information sharing and the use of technology to communicate. They are increasingly using the Internet to manipulate the grievances of alienated youth, radicalize them, and give them a sense of purpose.²⁷⁶

Targeted information posted on social media “lures its users with a promise of friendship, acceptance, or sense of purpose.”²⁷⁷ These same technologies can also be used for command and control purposes²⁷⁸ allowing decentralized, leaderless organization of global terrorism.²⁷⁹ The adaptation of the organization and practice of jihadists to fit the functionality provided by the Internet has reached the point that Marc Sageman claims that “the structure of the Internet has become the structure of global Islamist terrorism.”²⁸⁰

Greater IT systemic power promotes the ability to radicalize and coordinate online.

6. Identity and Radicalization

A sense of ontological insecurity, of feeling threatened, coupled with the dynamics of dynamics of personal identity can create a situation conducive to conflict or terrorism. According to social identity theory, some aspects of identity that can have an impact on likelihood that someone will be involved in terrorism are:

²⁷⁵ Sageman, *Leaderless Jihad*, 114.

²⁷⁶ Robin L. Thompson, “Radicalization and Use of Social Media,” *Journal of Strategic Security* 4, no. 4 (2011): 168.

²⁷⁷ *Ibid.*, 168.

²⁷⁸ Sageman, *Leaderless Jihad*, 114.

²⁷⁹ *Ibid.*, 121.

²⁸⁰ *Ibid.*

- *Cultural identity*—cultural values that a person uses as guiding principles for behavior.²⁸¹ Cultural values that make a person amenable to terrorist activity include “collectivism,” (a tendency to prioritize their group over themselves), “absolutism” in belief, and a strong sense of “familism,” a strong loyalty to family and organizations local to the individual.²⁸²
- *Social identity*—how someone identifies with members of one’s own group (their in-group) and those outside that group (the out-group), especially those groups that stand in opposition to the in-group. Under certain conditions, the in-group/out-group dichotomy can become an us-verses-them outlook.²⁸³ Nationalism and religion are powerful “identity signifiers in times of ontological insecurity and existential anxiety.”²⁸⁴
- *Personal identity*—a person’s self-definition, “particularly with respect to those goals, values, and beliefs that they hold in such domains of concern as vocation, religion, politics, family roles, gender roles, ethnicity, and personal interests.”²⁸⁵ Two particular situations related to personal identity that are relevant to the prospects for terrorism are: “authoritarian foreclosure,” which is an “adaptation of commitments” without considering alternatives, and “aimless diffusion,” which is the “absence of personally meaningful identity commitments and by confusion about how such commitments might be formed.”²⁸⁶

Interactions among the cultural, social, and personal aspects of identity can make a person more likely to commit terrorism. Collectivism and religious absolutism, especially in the context of an “us-verses-them” outlook and familism, especially if it is associated with the perception of injustices inflicted on one’s family or clan, can make terrorism more likely.²⁸⁷ Also, a social identity in the context of an us-verses-them outlook by which members of the out-group are demonized or there is a sense alienation from social institutions can increase the chances of violent radicalization.²⁸⁸ The way that

²⁸¹ Seth Schwartz, Curtis Dunkel, and Alan Waterman, “Terrorism: An Identity Theory Perspective,” *Studies in Conflict & Terrorism* 32 (2009): 540.

²⁸² *Ibid.*, 540–542.

²⁸³ *Ibid.*

²⁸⁴ Kinnvall, “Globalization and Religious Nationalism,” 757.

²⁸⁵ Erikson, *Identity, Youth, and Crisis*; James E. Marcia et al., *Ego Identity: A Handbook for Psychosocial Research* (New York: Springer-Verlag, 1993) as cited in Schwartz, Dunkel, and Waterman, “Terrorism: An Identity Theory Perspective.”

²⁸⁶ Schwartz, Dunkel, and Waterman, “Terrorism: An Identity Theory Perspective,” 544–545.

²⁸⁷ *Ibid.*, 546.

²⁸⁸ *Ibid.*

identity affects groups or individuals and results in conflict or terrorism varies. Security or lack of security can be seen as a “thick signifier,” which means that it entrails contextual aspects that imply “a specific metaphysics of life” that helps to define our place in the world and relationship with the world and with others.²⁸⁹ Of the elements listed above as contributing to terrorism, the only one that appears to be necessary, and without which terrorism will not occur, is the perception of threat to the in-group.²⁹⁰

Ontological insecurity (the feeling of being under threat) can resonate with the **cultural, social, and/or individual identity** of individuals or groups and facilitate the development of the **Threat of identity based conflict, terrorism**

The growing feeling of “ontological insecurity” is felt worldwide; however, the Muslim world appears to be experiencing and responding to a feeling of ontological insecurity with more intensity than many other cultures. According to Moghaddam:

complex political, economic, social, and psychological factors have combined to create circumstances in which Muslim communities in both western and non-western countries, and practicing Muslims in particular, fundamentalist Muslims even more so, feel collectively threatened.²⁹¹

In the case of people in Muslim communities, the loss of control arises from a threat to their culture, values, and identity.²⁹² Moghaddam observes, “One of the detrimental consequences [of globalization] is the rise of Islamic fundamentalism and terrorism.”²⁹³

Note the overlap between civil conflict and the identity-based conflict and terrorism. The chances that income inequality will lead to civil unrest are increased if identity divisions and other grievances coincide with inequality divide. For this reason, the diagram has arrows going from each of these threats to the other.

²⁸⁹ Kinnvall, *Globalization and Religious Nationalism*, 744–745.

²⁹⁰ Schwartz, Dunkel, and Waterman, “Terrorism: An Identity Theory Perspective,” 546.

²⁹¹ Moghaddam, *How Globalization Spurs Terrorism*, 109.

²⁹² *Ibid.*, 121.

²⁹³ *Ibid.*, 79.

M. ASYMMETRIC ATTACK

As we have explained earlier in this paper, the idea of entropy can mean different things in different contexts. We have explained how living social systems export their entropy to their environment, and when other social systems are in that environment, they can receive that exported entropy. These entropy transfers can be incidental and unintended, or they can be intentional and even strategic. Now, we will explore situations where one entity transfers entropy to another in a strategic and asymmetrical way.

1. Strategic Entropy Transfer

This paper is about how transfers of entropy in the environmental, social, and economic aspects of the U.S. homeland and its surrounding environment (the world) can affect our homeland security. Recall Castells's assertion that "human societies are made from conflictive interaction between humans organized in and around a given social structure."²⁹⁴ Our scalable model has illustrated how social structures can be understood in the context of entropy transfers among the environmental, social, and economic aspects of a living social system. Such social systems, in competition with each other for scarce inputs, can export entropy to one another indirectly without the conscious intention to do harm. In overt conflict, however, competing "organisms" can also consciously and strategically direct flows of matter, energy, and informational resources involving against one another, up to and including violence, in order to transfer entropy to an opponent in order to promote a longer term goal of promoting their own self-organization.

I suggest that there is a continuum of entropy transfers ranging from incidental transfers due to random environmental events through interactions among organisms from indirect and coincidental entropy transfers to specific, conscious, and targeted violence. Many of these modes of entropy transfer can be manipulated in strategic ways to accomplish specified objectives. If these different means of entropy transfer are consciously and asymmetrically used to attack an enemy, we could say that they are

²⁹⁴ Castells, "Materials for an Exploratory Theory of the Network Society," 7.

being employed in asymmetrical warfare. A pair of Chinese colonels has explained how this can be done.

2. “Unrestricted Warfare” and Asymmetrical Warfare

Qiao Liang and Wang Xiangsui are the two colonels in the Chinese People’s Liberation Army (PLA) who wrote the book *Unrestricted Warfare*, which notes how the process of globalization is changing the world and changing the frame of reference from which to view the subject of warfare:

The Great fusion of technologies is impelling the domains of politics, economics, the military, culture, diplomacy, and religion to overlap each other... Warfare is now escaping from the boundaries of bloody massacre, and exhibiting a trend towards low casualties, or even none at all, yet high intensity. This is information warfare, financial warfare, and other entirely new forms of war, new areas opened up in the domain of warfare. In this sense, there is now no domain which warfare cannot use, and there is almost no domain which does not have warfare’s offensive pattern.²⁹⁵

Furthermore, “military, politics, economics, culture, and the psyche [psychology] are also battlefields” in unlimited warfare.²⁹⁶

Note the overlap between the concept of “unrestricted warfare” and the sources of homeland security threats currently facing the U.S. identified in this paper: the roles of economics, information, finance, culture, psychology, and religion have been mentioned in the analysis of homeland security threats.

Qiao and Lang recognize the full spectrum of conflict inherent in human relations and make it the object of strategic analysis an application of an expanded concept of warfare. In this context, homeland security threats can be seen as not only the results of entropy processes but also potential tools that can be exploited by an adversary in unrestricted warfare. The struggle for needed inputs at the national and other levels can be seen as a struggle at different levels to counter one’s own entropy, and export it to others. The resulting conflict could be called entropy warfare. The colonels look for

²⁹⁵ Laing Qiao and Xiangsui Wang, *Unrestricted Warfare* (Beijing: PLA Literature and Arts Publishing House, 1999), 198.

²⁹⁶ *Ibid.*, 206.

creative ways to employ their understanding of the dynamics of conflict at these different levels. In their words: “Multidimensional (multiple spheres and multiple forces) coordination refers to coordination and cooperation among different forces in different spheres in order to accomplish an objective.”²⁹⁷ Additionally, they look to the dynamic of conflict for each level of interaction to identify how the interactions that are occurring can be consciously exploited alone and in creative combinations to ensure the maximum effectiveness. To quote Qiao and Lang, “the trend toward no limits is a trend toward continual enlargement of the range of selection and the methods of use of measure.”²⁹⁸ In other words, the colonels look to the competitive dynamics of different fields and hierarchical levels and seek to combine them to form an integrated strategy for their nation as an integrated, multi-level, social, economic, military, strategic (and I would add, environmental) entity. Therefore, unrestricted warfare can be seen as full spectrum entropy warfare, based on exploitation of the conflictive nature of social structures, and conducted at all levels.

Without using the word “networks,” the Chinese colonels emphasize that the concept of the nation state “is no longer the sole representative occupying the top position in social, economic and cultural organization.”²⁹⁹ They note “the emergence of large numbers of meta-national, trans-national, and non-national organizations, along with the inherent contradictions between one nation and another, are presenting an unprecedented challenge to national authority, national interests, and national will.”³⁰⁰ These organizations are networks. Recall from Castells that in network society, networks are a driving force of globalization and a primary threat to the role of the national state. In unlimited warfare, networks have become a main field of battle among states and other entities in the network world. Many of these battles are on the front lines of the war for U.S. homeland security. Proper analysis of the dynamics of interactions in these networks in the context of the larger global environment is key to formulating successful offensive

²⁹⁷ Ibid., 213.

²⁹⁸ Ibid., 210.

²⁹⁹ Ibid., 220.

³⁰⁰ Ibid.

and defensive strategies. Understanding the interactions of factors at various levels and how one's strengths can be used against an adversary's weaknesses on any level will likely lead to an "asymmetrical" approach. Qaio and Wang view asymmetry "as a principle is an important fulcrum for tipping the normal rules in beyond limits ideology."³⁰¹

3. Homeland Security and National Security in the Context of Unrestricted Warfare

Buffaloe sees "a common thread among all the various threats that asymmetry seems to represent: insurgency, cyber-terrorism, bioterrorism, improvised explosive devices, 9/11 (and) WMD proliferation," which are the ideas of *Unrestricted Warfare* applied to Clausewitz's ideas from *On War*. This is that "each act is simply "politics through other means."³⁰²

An understanding of the dynamics creating the homeland security threats could be invaluable information, a blueprint, for an adversary intent on waging unrestricted warfare against the U.S. From a defensive standpoint, systemic understanding of the global causes of homeland security threats that can be exploited in an asymmetric attack can be used to develop countermeasures to such attacks. From an offensive perspective, understanding sources of entropy in another country could be used to leverage these weaknesses in a directed, strategic, and asymmetrical way.

Many of the homeland security threats in this paper can be exploited so as to represent the **threat of asymmetrical attack**.

Politics, diplomacy, and the military are mentioned by the colonels as aspects of unlimited warfare to be employed in conjunction within the theaters of unlimited warfare described above. Politics, diplomacy, and the military are largely considered to be within the realm of national security in the U.S., but they blend seamlessly with economics, culture, religion, information, psychology, and finance in the colonels' conception of

³⁰¹ Ibid., 211.

³⁰² David Buffaloe, *Defining Asymmetric Warfare* (Arlington, VA: The Institute for Land Warfare, 2006), 16.

unlimited warfare. This raises the question of the proper boundary between homeland security and national security. Has the boundary been drawn on the basis of logic or has a boundary been arbitrarily erected that divides a unified problem space into two separate fields? From the perspective of unlimited warfare, the American distinction between homeland security and national security appears to be an artificial one. It also seems that the sources of homeland and national security threats arise from essentially the same global processes that we have studied in this paper. If the boundary between national and homeland security has been arbitrarily drawn, do the current linkages between the U.S. national security establishment and the homeland security enterprise facilitate a level of coordination that properly corresponds to the interdependence of homeland security and national security threats?

N. THE TREND MAP

The last two chapters have been organized around the construction of a diagram or trend map visually illustrating how global processes of self-organization generate entropy flows that give rise to the homeland security threats that have been the topic of this paper. The diagram visually summarizes these chapters and is Figure 8. The central part of the diagram is Figure 7 that was explained in Chapter V and represents the self-organizing dynamic of globalization. The current chapter has been about how these processes of self-organization give rise to entropy transfers that culminate in homeland security threats. The two chapters together illustrate how homeland security threats can be understood in a coherent and unified way. Threats are underlined and in bold font and positioned just inside the outermost ring on the diagram. The map is read from the inside out. Arrows show the direction of causality. The pattern of self-organization in one part of an open system resulting in a transfer of disorder to another part is consistent with the characteristics of a dissipative system.

The factors that are shown in the map have been topics in the preceding text and were labeled in bold font. The short summaries in the text boxes summarize the components of the trend map and convey the causal direction of the trends. Some of these causal linkages are straight lines radiating out from the center, leading to the homeland

security threats. The concentric rings, some of which are broken, illustrate other causal linkages among factors illustrated in the map. Some of these lateral linkages have been mentioned in the text. There are instances where there are multiple linkages on the same concentric ring, such as on the fourth ring out from the center that has *immigration, skill-biased technological change, automation, offshoring of production, and jobs loss due to trade competition* all flowing in the same direction and contributing to *growing income inequality*. On the same ring, however, a directional arrow points in the other direction to indicate how *greater IT systemic power, complexity, vulnerabilities* facilitates *cyber espionage*, which contributes to the *diffusion of military, dual use tech*.

The presence of these lateral linkages illustrates that many trends have multiple, mutually reinforcing causes. This multiple, mutually reinforcing nature of causality is part of what makes this system “complex.” Another illustration is that, *downward wage pressure, pollution* and many other causes contribute to *human migration*. At the same time, *improved transportation* also facilitates *migration*. War and *civil conflict* are two other causes of migration mentioned in the text, but not illustrated in the map to prevent it from becoming too cluttered. Note that *war* is not on the diagram because it is not considered a homeland security threat (it is under national security), but many factors shown on the diagram can be seen as contributing to the likelihood of war, such as *resource depletion, threat of civil conflict, and the threat of identity-based conflict or terrorism*. This means that there are many potential causal linkages not shown in the trend map.

Many of the homeland security threats identified in this paper are also shown to be potential modes of asymmetrical attack, and this is illustrated by the threats whose arrows intersect the outermost ring, which leads to threat of asymmetrical attack. The arrow for threat of asymmetrical attack is pointed inwards to save space and signify that all the arrows that intersect this outermost ring can be exploited in an asymmetrical attack.

Figure 8 is at best a crude approximation of what is going on. It does not capture all the subtlety and nuance of the forces shaping the U.S. homeland security environment, nor does it claim to. Trend map may, however, in an imprecise and descriptive way,

illustrate how complex processes of self-organization can give rise to actual homeland security threats. In short, the diagram illustrates how the homeland security threats can be seen as related to fundamental process of self-organization occurring in the world, and each other. They are all part of the same metaphorical elephant, and the elephant acts like a dissipative system. With additional time and resources, more nuanced analysis could be conducted that could provide even more useful import to homeland security policy making.



Figure 8.

Figure 8. The homeland security trend map

VII. CONCLUSIONS

A. THE HOMELAND SECURITY ENVIRONMENT AS A COMPLEX SYSTEM

This thesis has explored the idea that the forces giving rise to threats to U.S. homeland security can be descriptively modeled as a dissipative system. The thesis notes the descriptive similarities with ideas from the literature about social, economic, and environmental topics related to homeland security to the characteristics of dissipative systems, such as entropy, self-organization, and multiple steady states. General systems theory (GST), living systems theory (LST), and social entropy theory (SET) are all approaches that claim to explain organized complexity at a global level, and all incorporate Prigogine's concept of entropy and dissipative systems as a foundational premise. Combined, these approaches provide a rich conceptual foundation for modeling the global environment that gives rise to U.S. homeland security threats as a dissipative system.

This paper used the approaches GST, LST, and SET to construct a generic scalable model of such a dissipative system with social, economic, and environmental aspects. Entropy transfers among these aspects of the social living system occur as the result of flows of matter, energy, and information, or objects composed of these factors.

The thesis also featured a simplified causal model, or trend map, based on a narrative explaining how fundamental processes of self-organization occurring in the world give rise to the real-world homeland security threats that we are experiencing today. The trend map illustrates that the environment affecting the homeland security of the U.S. exhibits the characteristics of a dissipative system in the sense that process of self-organization give rise to homeland security threats (disorder, entropy) and the causal mechanisms that accomplish this can be identified.

The origins of homeland security threats can be seen as complex because:

- Homeland security threats are the result of non-equilibrium, irreversible processes,

- The causes of homeland security threats are composed of multiple factors and can have multiple, mutually-reinforcing causes, and
- The relationships among these factors and causes can change in non-linear, unexpected ways over time.

This thesis has illustrated that self-organized criticality is a characteristic of many of the systems relevant to homeland security analysis. Self-organized criticality is a characteristic of dissipative systems. Therefore, the presence of self-organized criticality in systems is relevant to homeland security analysis is a further indication of the usefulness of analyzing the homeland security environment from the perspective of dissipative systems. Even given the limitations of this thesis, there is considerable evidence that the homeland security threats can be understood in terms of entropy and self-organization in a dissipative system.

Entropy transfers in a social system are observable and sometimes roughly measurable using money as an entropy marker. Net entropy transfers within and among nations occur through processes of social and economic self-organization and entropy, and they can often have a harmful effect (whether intended or not). Whether entropy transfers are considered beneficial or harmful depends upon the selection of the unit of analysis, since self-organization beneficial from the perspective of one part of a system can result in detrimental entropy from the perspective of another.

The concept of social free energy provides an overall system measure of entropy and, when combined with using money as an entropy marker, may serve as a proxy measure of overall homeland security. From this perspective, homeland security can be seen as an overall system property. By further developing entropy markers and systemic entropy concepts, such as the social free energy, homeland security can be understood in terms of a balance between self-organization and entropy that manifests itself in various, but related and understandable ways.

Together, the scalable model and the trend map illustrate that homeland security threats and their causes can be understood in as an integrated whole in the context of the entropy law—one of the most fundamental ideas in all of science. In terms of the parable

of the *blind men and the elephant*, the pillar, tail, wall, and fan that had been perceived earlier can now be understood as a single, complete elephant.

B. THE ECONOMIC, SOCIAL, AND ENVIRONMENTAL DETERMINANTS OF HOMELAND SECURITY

This paper has sought to understand homeland security in a global context. For example, the scalable model subdivided a generic living social system into economic, social, and environmental components, whose dynamics are interrelated over time in a circular and cumulative way. This paper has pointed out the fundamental importance of our national economy to homeland security by noting that the nation with the lead economy from the perspective of innovation and the ability to influence the shape of the global system has an advantage in acquiring the inputs that it needs to self-organize and export entropy. A nation that loses its status as lead economy may find itself as a net importer of entropy from the new lead economy. Given the interdependencies among the social and economic factors, loss of economic leadership by the U.S. would cause changes in the global and domestic political situation of the U.S., and most likely for the worse. From this perspective, maintaining U.S. economic and global leadership has great significance for homeland security.

The social, economic, and environmental aspects of the U.S. as a living social system interact with its external environment, the rest of the world. That world is now experiencing accelerating change. Globalization has led to an increasingly integrated global market. Recall from earlier discussion that the ongoing process of economic creative destruction among enterprises is mediated by markets. Globalized markets have the power to mediate the distribution of creation or destruction of firms throughout the world. Maintaining U.S. economic leadership means ensuring that the dynamic of creation is centered here in the United States, otherwise a dynamic of economic destruction may take hold. A better developed methodology for measuring entropy flows could be used to determine the impact of different policy options on total system entropy, which could help policymakers develop policies that facilitate self-organization and mitigate overall system entropy, and inform homeland security thinking at a strategic level.

This thesis has proposed that many of the homeland security threats can be leveraged and exploited in an asymmetrical manner against the United States. By a similar token, an understanding of the entropy dynamics driving the homeland security threats of an adversary can also be used for offensive asymmetrical warfare purposes. The concept of activating and leveraging entropy processes in the economic, social (including political), and environmental realms of adversarial groups and societies could form the basis of an expanded concept and practice of asymmetrical warfare.

C. THE ROLE OF GOVERNMENT IN HOMELAND SECURITY BEYOND THE HOMELAND SECURITY ENTERPRISE

Government policies that affect the economic, social, and environmental situation of the United States also have impacts on forces that affect U.S. homeland security. This means that the conceptual space of “homeland security” thinking should be expanded into the economic, social, and environmental realm as well. Much of the government policy that affects the U.S. homeland security is not under the control of the Department of Homeland Security. The irreversible processes driving homeland security threats are continually evolving: they will change over time—for better or worse—but their effects can be mitigated. If we are able to correctly identify the drivers of entropy and the linkages among the different aspects of the global environment related to homeland security can be identified and understood, then there may be opportunities to interdict some of these processes and enhance our homeland security. Such an expanded concept of homeland security policy formulation should be based on an accurate understanding of the linkages between social, economic, and environmental processes and homeland security.

Homeland security threats can be seen the by-products, or externalities, of long-term, global processes. This paper has claimed that these processes are largely self-organizing and may be considered to be, on the whole, beneficial. At the same time, the earth is essentially closed a system receiving sunlight and occasional space debris. As the global population grows, technology advances, more energy is consumed and dissipated, and the world economy continues to develop and integrate under conditions of intensifying competition, we can expect that the self-organization of the global economy

to continue to intensify. This intensification could also result in the production of increasing amounts of environmental, social, and economic entropy. Environmental entropy in the form of environmental pollution and degradation may constitute a reduction in the earth's capital stock, which limits the capacity to produce food. If the threat of global warming fully materializes, it will exacerbate many homeland security threats. In the future, fragmented global governance will likely complicate the regulation of both legitimate and illegal transnational and global enterprises, including efforts to mitigate the development of self-organizing criticality that can be expected to continue to develop in various global systems. For all these reasons, for the foreseeable future, governments will be severely challenged to fundamentally change these processes. For that reason, homeland security threats that are caused by these processes can be expected to continue into the indefinite future.

We can expect global systems to become more integrated, complex, and optimized due to market-based competition. This implies an increase in the self-organized criticality of these emerging global systems, perhaps leading to more frequent and intense catastrophes. If action is not taken to mitigate self-organized criticality, we may expect a tendency toward increased self-organized criticality in the following realms:

- The physical environment
- Economy and financial markets
- Critical infrastructure
- Disease transmission
- Catastrophic evolution

Government policies that facilitate the creation of inputs needed to maintain economic and global leadership will have a strong influence on the long-term homeland security situation of the country. Over the long run, policy areas, such as macro-economic policy, monetary policy, trade and investment policy, financial and business regulation, and education, can have as profound impacts on the homeland security position of the U.S. as traditional DHS functions. This means that the impact of government policy on homeland security goes well beyond the actions of DHS, and it entails the effects of all

government policy on the dynamics of entropy and self-organization affecting the internal and external environment of the United States. In order to attract needed inputs, a system must be open, but just because a system is open does not mean it will selectively attract those inputs that best facilitate its self-organization. Government policy can contribute to this goal but here are significant limitations on what is possible.

This paper has claimed that economic and social systems are the product of entropy and self-organization on the basis of a rich foundation of concepts from GST, LST, and SET. Castells has claimed that that in the evolving network society, power is being transferred from hierarchies to networks, and this is circumscribing the power of the state while associated developments are discrediting the state. The world economy is transitioning to production based on globalized networks and global corporations, and globalized financial markets. Sovereignty is devolving to international and supranational organizations. Fragmented international governance is creating opportunities for the emergence of organized crime on a global scale. In this context, U.S. government policy, while significant, becomes just another factor among many affecting the course of self-organization that is occurring within the U.S. and abroad. This creates a challenging situation for U.S. policy makers. On the one hand, policy makers should recognize the significance of social, economic, and environmental policy on the overall homeland security situation of the United States. On the other hand, policy makers must understand the implications of what Castells calls the power of flows taking precedence over the flows of power for making policy. Policy makers must devise policy that implicitly understands and leverages the logic of networks and markets to achieve desired outcomes. In other words, policy has to create the incentives and conditions that will steer the processes of self-organization in the desired direction. This task is complicated by the complex and dynamic nature of the emerging global society makes it difficult to predict or measure the actual impact of any policy.

This paper has illustrated how flows of matter, energy, and information and their carriers may promote self-organization in an open system. The role of government in promoting homeland security beyond the homeland security enterprise consists of influencing these flows to promote self-organization in the social, economic, and

environmental aspects of our nation. Some related policy areas include social, economic and environmental.

1. Social

- The development and maintenance of a “social structure of accumulation”—a broad social and political accord coupled with a complimentary institutional framework that incents the investment needed to launch and sustain long term economic growth.
- Education—especially education that allows workers to be what Castells calls “self-programmable” and able to operate within the global network economy, as opposed to generic labor which is exchangeable and disposable.
- The openness of society as a system. Along with matter and energy, flows of information drive self-organization. Policies that affect the flow of information therefore affect the nature of self-organization, or entropy occurring in the country. Communications technology and networks obviously affect the cost and efficiency of communications. Another important source of information for the allocation of resources in society is markets. Government policies should seek to leverage the logic of networks and markets to facilitate self-organization within the United States.
- Immigration—finding the right combination of policies that facilitate the immigration of people likely to positively contribute to the ongoing “self-organization” of the United States while also creating conditions conducive to the success of the immigrants.

2. Economic

- Voluntary trade makes both participants better off in the present. As mentioned previously, the exchange of goods and services also plays a direct role in “creative destruction” and entropy transfers, facilitates linkages in the “network economy” and can also be a battlefield of asymmetric warfare. We should balance our position accordingly.
- Economic policies that follow the logic of networks and markets to promote self-organization will ultimately have beneficial consequences for U.S. homeland security. Economic policies that do not follow this logic will not.
- Policy makers should be mindful of long term negative consequences of national debt from the standpoint of money being an entropy marker. More debt means the exportation of resources, and the corresponding importation of entropy, later.

3. Environmental

- Policies that can halt or mitigate the adverse effects of this climate change will definitely enhance U.S. homeland security.
- Policies that can reduce or mitigate environmental degradation and the loss of economic “fund” items, such as soil and water will reduce the impact of entropy processes on our country.

Although the governmental functions that came under the DHS umbrella already existed, the factors that put the U.S. in its leading position are better expressed in terms of conditions that led to American economic global leadership were already in place. These conditions include an open, dynamic, and innovative economy supported by a well-educated, open society and general political accord which facilitates efficient and effective capital formation. Upon reflection, it should come as no surprise that many of the main determinants of homeland security are not under the jurisdiction of DHS. DHS was founded as a response to the 9–11 terror attacks without even a well-defined concept of “homeland security.” At the time of the attacks, the U.S. was already the world’s sole superpower, lead economy, and leader of the global order—an enviable position underpinning U.S. security with multifaceted levers of American power. The homeland security enterprise did not create these pillars of American power and security, but perhaps it can help maintain them. This observation calls into question the validity of thinking about homeland security solely in terms of the evolving ‘homeland security enterprise’.

This paper has tried to show that many homeland security threats can be understood as being related to deeper, interrelated, evolving social, economic, and environmental processes. The resolution of homeland security threats that we are facing now, and will likely face in the future, will require a cognitive framework that systematically identifies the root causes of the threats. An open systems approach based on the dynamics of entropy and self-organization can provide a unifying basis for understanding homeland security threats.

While focusing on homeland security and mostly omitting national security, this paper has demonstrated that the homeland security environment is global in nature, as is the national security environment. This raises the possibility that the way the U.S.

separates national and homeland security may essentially be arbitrary. Many of the threats are essentially the same. A systems approach to the common national security and homeland security environment could provide a tool for integrating homeland and national security policy formulation. National and homeland security functions could be viewed as complimentary aspects of an overall strategy to promote self-organization and impede entropy in the United States, in a context of intensive, if not always intentional or overt, competition in the social, economic, and environmental aspects of our national existence. In other words, both national and homeland security policy should guard against entropy warfare or its cousin unlimited warfare.

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VIII. OPPORTUNITIES FOR FURTHER RESEARCH

This paper has explored the idea of descriptively modeling the origins of homeland security threats facing the U.S. as an open dissipative system. Due to its limitations, this paper provides many opportunities for further research.

The causal map of the U.S. homeland security environment presented in this paper has significant limitations. Due to the scope of this paper, the main objective was to demonstrate the validity of the concept. There is certainly opportunity to add greater nuance and granularity. Also, since the homeland security environment is a dynamic, complex system, it will evolve and change over time, and therefore the map must be updated as the situation and thinking about homeland security change.

This paper has argued that the concepts of entropy and social free energy can be used as proxies for overall homeland security, which can then be viewed as a system property. An argument was made that money is an entropy marker, and that financial reports can therefore provide detailed information about overall entropy flows in a system. Linkages between the economy and other aspects of social life have been studied and documented to a level of detail beyond the scope of this paper. There is much scope for incorporating existing knowledge and additional work on these subjects by further exploring the links between economic variables and social and environmental aspects of homeland security.

A dissipative system model appears to be a promising approach to understanding the complexities of the homeland security environment. This paper has dealt applied the idea of a dissipative system in the simplest, most descriptive way possible. The literature about dissipative systems contains a broad array of other features that could perhaps be used to model phenomena in social, economic, and environmental systems and could be explored further. For example, the results of using self-organization theory to model the global process U.S. within its homeland security environment as a complex adaptive

system³²⁰ would be interesting and could yield valuable insights. Also, complexity catastrophe theory³²¹ also deals with the dynamics of dissipative systems, seems somewhat similar to self-organized criticality, and could also be applied to systems related to homeland security.

This paper also called into question the demarcation between homeland and national security. Future research could use a complex system approach to modeling the global environments in which the national security and homeland security communities operate and note where there are actual differences and where there are overlaps. The areas where there are overlaps, and the analysis done in this paper implies that there should be many, are places to assess how well the linkages between homeland and national security are functioning in order seek improvements. A detailed understanding of the underlying causes of homeland security and national security threats can provide insights into exactly how to improve these linkages.

³²⁰ Bill McKelvey, "Self-Organization, Complexity Catastrophe, and Microstate Models at the Edge of Chaos," in *Variations on Organization Science: In Honor of Donald T. Campbell*, ed. Bill McKelvey (279–307) (Thousand Oaks, CA: SAGE, 1999), 282.

³²¹ *Ibid.*, 279.

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